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T. E. WIDNER

Y/UB-10

ENVIRONMENTAL MONITORING REPORT

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE FACILITIES

Calendar Year 1978

UNION CARBIDE

NUCLEAR DIVISION
OAK RIDGE, TENNESSEE

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Calendar Year 1978

UNION CARBIDE CORPORATION – NUCLEAR DIVISION
Oak Ridge Gaseous Diffusion Plant
Oak Ridge National Laboratory
Oak Ridge Y-12 Plant

Office of Health, Safety, and Environmental Affairs
Post Office Box Y
Oak Ridge, Tennessee 37830

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INTRODUCTION

Oak Ridge is located in East Tennessee in a broad valley which lies between the Cumberland Mountains on the northwest and the Great Smoky Mountains on the southeast. The Department of Energy (DOE) Reservation is located in the Valley and Ridge physiographic province which is characterized by parallel ridges of sandstone, shale, and cherty dolomite, separated by valleys of less weather-resistant limestone and shale. The ridges are oriented southwest-northeast. Topography of the area is due to differential erosion of severely folded and faulted rocks ranging in age from Early Cambrian to Early Mississippian. Elevations range from 226 meters to 415 meters above mean sea level with a maximum relief of 189 meters. The area includes gently sloping valleys and rolling to steep slopes and ridges. The Tennessee Valley Authority's (TVA) Melton Hill and Watts Bar Reservoirs on the Clinch River form the southern and western boundaries of the Reservation while the City of Oak Ridge (approximately 28,000 population) is on the northern boundary.

The local climate is noticeably influenced by topography. Prevailing winds are usually either up-valley, from west to southwest, or down-valley, from east to northeast. During periods of light winds, daytime winds are usually southwesterly and nighttime winds usually northeasterly. Wind velocities are somewhat decreased by the mountains and ridges, and tornadoes rarely occur. In winter, the Cumberland Mountains have a moderating influence on the local climate by retarding the flow of cold air from the north and west. Temperatures of 38°C or higher and-18°C or below are unusual. Low-level temperature inversions occur during approximately 56 percent of the hourly observations. Winter and early spring are the seasons of heaviest precipitation with the monthly maximum normally occuring during January to March. The mean annual precipitation is approximately 137 centimeters.

The topography of the Oak Ridge Area is such that all drainage from the DOE Reservation flows into the Clinch River which has its headwaters in southwestern Virginia and flows southwest to its mouth near Kingston, Tennessee. The Clinch River flow is regulated by several dams which provide reservoirs for flood control, electric power generation, and recreation. The principal tributaries through which liquid effluents from the plant areas reach the Clinch River are White Oak Creek, East Fork Poplar Creek, and Poplar Creek.

With the exception of the City of Oak Ridge, the land within 8 kilometers of the DOE Reservation is predominantly rural being utilized largely for residences, small farms, and pasturage for cattle. The approximate location and population of the towns nearest the DOE Reservation are: Oliver Springs (pop. 3400) 11 kilometers to the northwest; Clinton (pop. 4800) 16 kilometers to the northeast; Lenior City (pop. 5300) 11 kilometers to the southeast; Kingston (pop. 4100) 11 kilometers to the southwest; and Harriman (pop. 8700) 13 kilometers to the west. Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 kilometers to the east and has a population of approximately 175,000. A directional 80-kilometer population distribution, which is used for population dose calculations later in this report, is shown in Table 1.

The DOE Reservation contains three major operating facilities: the Oak Ridge National Laboratory (ORNL), the Oak Ridge Gaseous Diffusion Plant (ORGDP), and the Y-12 Plant; all of which are operated by Union Carbide Corporation, Nuclear Division. In addition, two smaller DOE facilities are in the area: the Comparative Animal Research Laboratory, and the Oak Ridge Associated Universities.

The Oak Ridge National Laboratory is a large multipurpose research laboratory whose basic mission is the discovery of new knowledge, both basic and applied, in all areas related to energy. To accomplish this mission, the Laboratory conducts research in all fields of modern science and technology. The Laboratory's facilities consist of nuclear reactors, chemical pilot plants, research laboratories, radioisotope production laboratories, and support facilities.

The Oak Ridge Gaseous Diffusion Plant (ORGDP) is a complex of production, research, development, and support facilities located west of the city of Oak Ridge. While the primary function of ORGDP is the enrichment of uranium hexafluoride (UF_6) in the uranium-235 isotope, extensive efforts are also expended on research and development activities associated with both the gaseous diffusion and gas centrifuge processes. In addition, the barrier material used by all three Department of Energy-owned gaseous diffusion plants is manufactured at ORGDP. Numerous other activities (maintenance, nitrogen production, steam production, uranium recovery, fluorine production, water treatment, laboratory analysis, administration, etc.) lend support to these primary functions and are thus essential to the operation of this plant.

The Oak Ridge Y-12 Plant which is located immediately adjacent to the City of Oak Ridge has four major responsibilities: (1) production of nuclear weapon components, (2) fabrication support for weapon design agencies, (3) support for the Oak Ridge National Laboratory, and (4) support and assistance to other government agencies. Activities associated with these functions include the production of lithium compounds, the recovery of enriched uranium from unirradiated scrap material, and the fabrication of uranium and other materials into finished parts and assemblies. Fabrication operations include vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

Operations associated with the DOE research and production facilities in Oak Ridge give rise to several types of waste materials.

Radioactive wastes are generated from nuclear research activities, reactor operations, pilot plant operations involving radioactive materials, isotope separation processes, uranium enrichment, and uranium processing operations. Nonradioactive wastes are generated by normal industrial-type support operations that include water demineralizers, air conditioning, cooling towers, acid disposal, sewage plant operations, and steam plant operations.

Nonradioactive solid wastes are buried in a centralized sanitary landfill or designated burial areas. Radioactive solid wastes are buried in designated burial areas or placed in retrievable storage either above or below ground depending upon the type and quantity of radioactive material present and the economic value involved.

Gaseous wastes generally are treated by filtration, electrostatic precipitation, and/or chemical scrubbing techniques prior to release to the atmosphere. The major gaseous waste streams are released through stacks to provide atmospheric dilution for materials which may remain in the stream following treatment.

Liquid radioactive wastes are not released but are concentrated and contained in tanks for ultimate disposal. Process water which may contain small quantities of radioactive or chemical pollutants is discharged, after treatment, to White Oak Creek, Poplar Creek, East Fork Poplar Creek, and Bear Creek, which are small tributaries to the Clinch River.

SUMMARY

The Environmental Monitoring Program for the Oak Ridge area includes sampling and analysis of air, water from surface streams, creek sediments, biota, and soil for both radioactive and nonradioactive materials. This report presents a summary of the results of the program for calendar year 1978.

Surveillance of radioactivity in the Oak Ridge environs indicates that atmospheric concentrations of radioactivity were not significantly different from other areas in East Tennessee. Concentrations of radioactivity in the Clinch River and in fish collected from the river were less than 3 percent of the permissible concentration and intake guides for individuals in the offsite environment. While some radioactivity was released to the environment from plant operations, the concentrations in all of the media sampled were well below established standards.

The total body dose to a "hypothetical maximum exposed individual" at the site boundary was calculated to be 6.4 mrem/yr which is 1.3 percent of the DOE Manual Chapter 0524 standard. The maximum 50-year dose commitment to the critical organ of an individual from the aquatic food chain was calculated to be 35 millirem to the liver which is 2.3 percent of the allowable annual standard. The maximum dose commitment to individuals living nearest the site boundary from airborne releases, assuming continuous residence, was 0.14 millirem to the total body and 1.0 millirem to the lung. These doses are 0.03 percent and 0.07 percent, respectively, of the annual standards. The average total body dose to an Oak Ridge resident was estimated to be 0.05 millirem as compared to approximately 100 mrem/yr from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 0.17 millirem. The cumulative total body dose to the population within an 80-kilometer radius of the Oak Ridge facilities resulting from 1978 effluents was calculated to be 5.6 man-rem. This dose may be compared to an estimated 74,000 man-rem to the same population resulting from natural background radiation.

Surveillance of nonradioactive materials in the Oak Ridge environs shows that established limits were not exceeded for those materials possibly present in the air as a result of plant operations with the exception of fluorides which exceeded the limits on two occasions. Several abatement projects to reduce fluoride emissions became fully operational in 1978.

The chemical water quality data in surface streams obtained from the water sampling program indicated that average concentrations resulting from plant effluents were in compliance with State stream guidelines with the exception of fluorides which were slightly over the limit.

National Pollutant Discharge Elimination System (NPDES) permit compliance information has been included in this report.

During 1978, the ORGDP incurred two reportable oil spills. One resulted from the malfunction of oil filtering equipment and the other from mishandling of a container by a roofing contractor. The Spill Prevention Control and Countermeasure (SPCC) Plan for the Plant has been revised and measures have been taken to reduce the probability of similar spills in the future.

MONITORING DATA
COLLECTION, ANALYSIS, AND EVALUATION

Environmental monitoring data for calendar year 1978 are summarized in Table 2 through 33. In general, the data tables show the number of samples collected at each location, the maximum concentration, the minimum concentration, the average concentration, the relevant standard, and percent of standard for the average of each parameter. Averages are usually accompanied by plus-or-minus (±) values which represent the 95 percent confidence limits. The 95 percent confidence limits which are calculated from the standard deviation of the average, assuming a normal frequency distribution, are predictions of the variability in the range of concentrations based on a limited number of measurements. They do not represent the conventional error in the average of repeated measurements on identical samples. Data which are below the minimum detectable limit are expressed as less than (<) the minimum detectable value. In computing average values, sample results below the detection limit are assigned the detection limit value with the resulting average value being expressed as less than (<) the computed value.

Average environmental concentrations are compared with applicable standards where such standards have been established, as a means of evaluating the impact of effluent releases. In some cases, for lack of an official standard, stream concentrations of nonradioactive pollutants have been compared with Tennessee State Health Department stream guidelines.

Liquid effluent monitoring data have been compared to the limits specified in the National Pollutant Discharge Elimination System (NPDES) permits issued to the Oak Ridge Facilities by the Environmental Protection Agency (EPA).

Air Monitoring

Radioactive - Atmospheric concentrations of radioactive materials occuring in the general environment of East Tennessee are monitored by two systems of monitoring stations. One system consists of nine stations (HP-31 through HP-39) which encircle the perimeter of the Oak Ridge area and provides data for evaluating releases from Oak Ridge facilities to the immediate environment, Figure 1. A second system consists of eight stations (HP-51 through Hp-58) encircling the Oak Ridge area at distances of from 19 to 121 kilometers, Figure 2. This system provides background data to aid in evaluating local conditions. Sampling for radioactive particulates is carried out by passing air continuously through filter papers. Filter papers are evaluated weekly by gross beta and gross alpha counting techniques and composited quarterly by system for specific radionuclide analysis during normal operations. More frequent detailed analyses are performed if concentrations in the environment are significantly above normal. Airborne radioactive iodine is monitored in the immediate environment (HP-31 through HP-39) by passing air continuously through cartridges containing activated charcoal. Charcoal cartridges are evaluated for radioactive iodine by gamma spectrometry.

Data on the concentrations of radioactive materials in air and the quantities of radioactive materials released to the atmosphere in the Oak Ridge and surrounding areas are given in Tables 2 through 6.

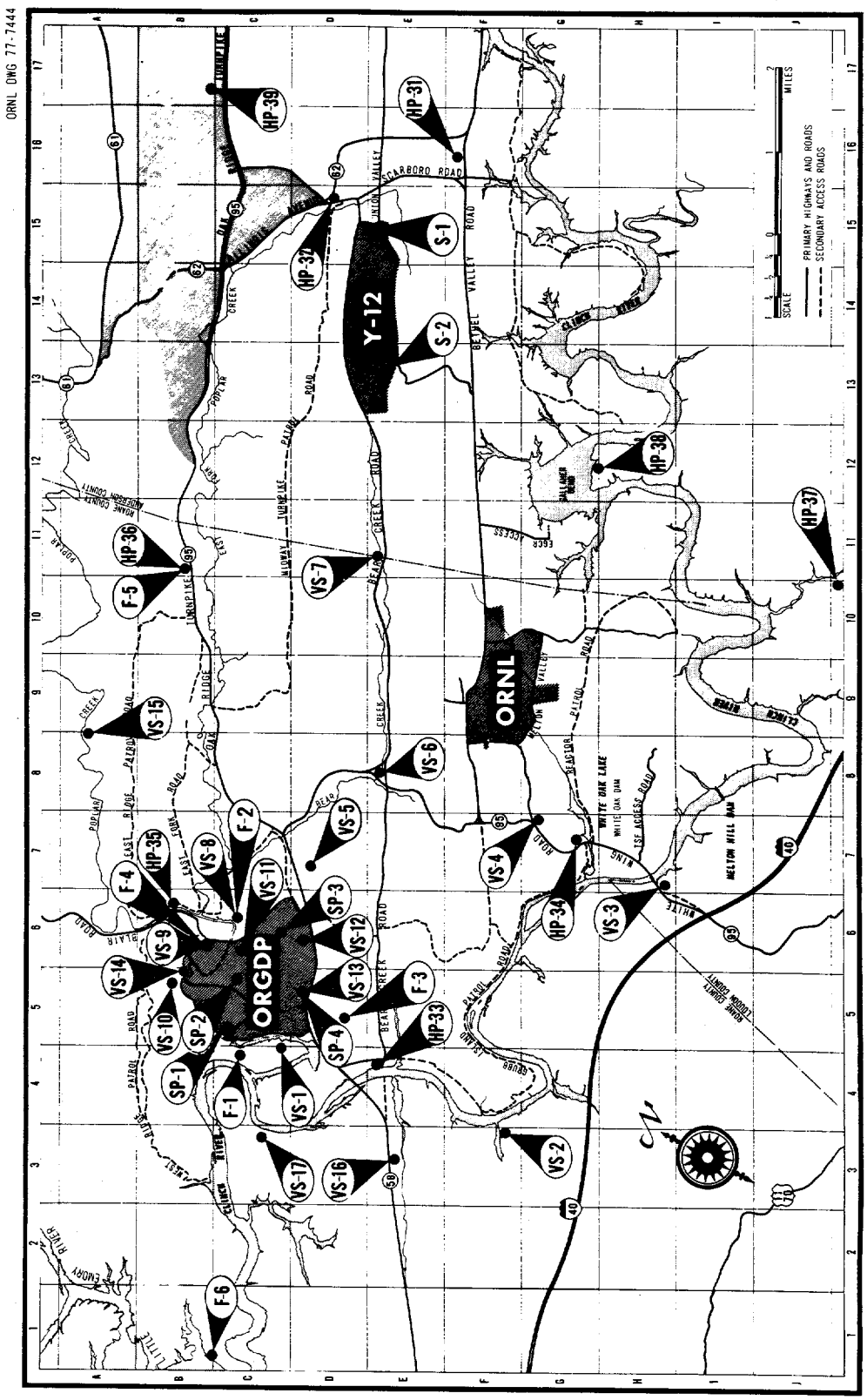

Figure 1
AIR, VEGETATION, AND SOIL SAMPLING LOCATIONS

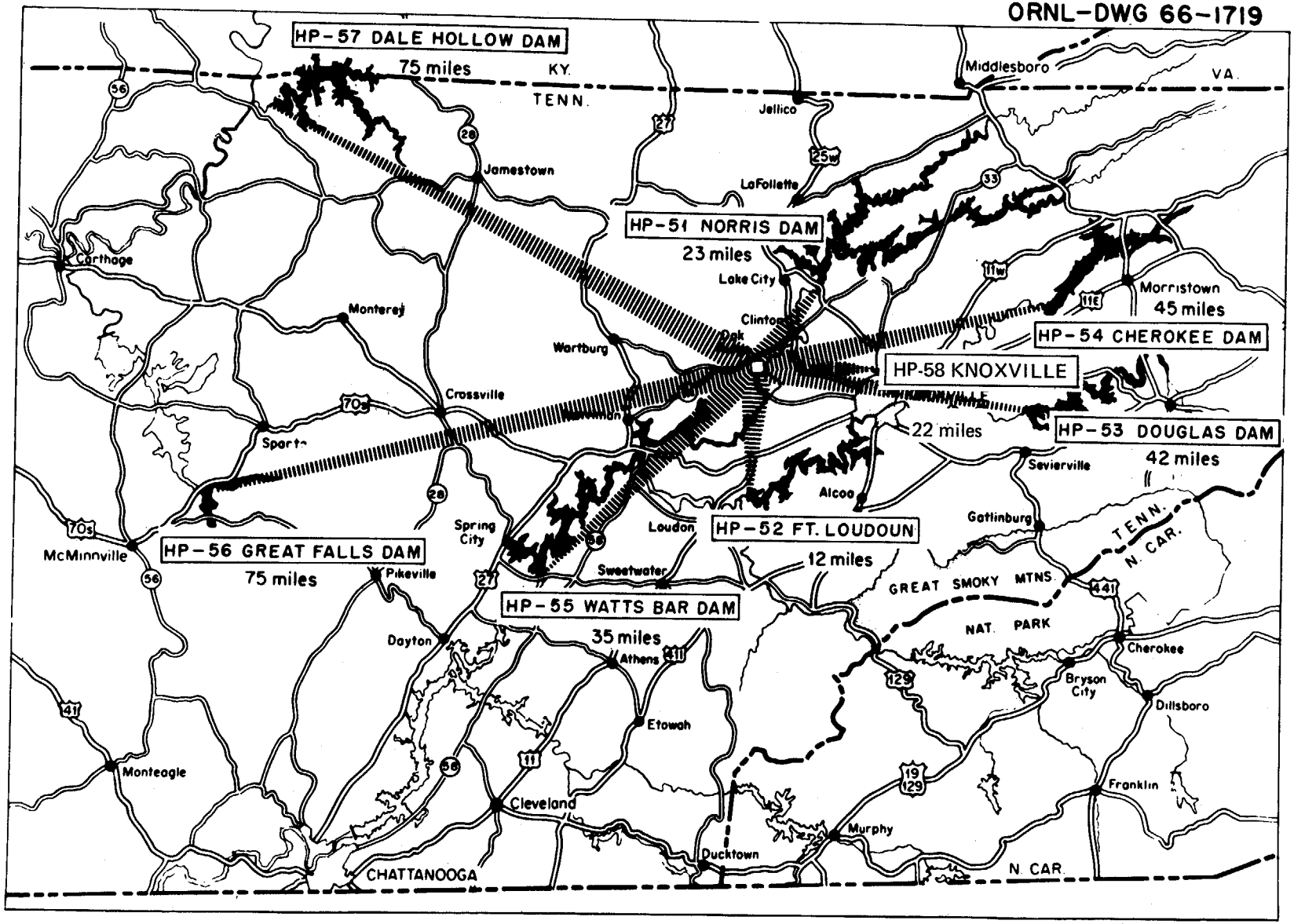

Figure 2

STATION SITES FOR REMOTE AIR MONITORING SYSTEM

The average gross beta concentrations of radioactivity from particulates in air measured by both the perimeter and remote monitoring systems were 0.07 and 0.08 percent, respectively, of the applicable concentration guide (CG) as specified in the DOE Manual, Appendix 0524[1] for individuals in uncontrolled areas (Table 2).

The average gross alpha concentrations in the perimeter and remote monitoring systems were both 0.03 percent of the CG for a mixture of uranium isotopes (Table 3).

The results of specific radionuclide analyses of composited filters are given in Table 4. The environmental concentrations tabulated are all at least a thousand times less than the applicable DOE concentration guides for the radionuclides detected.

The concentration of ^{131}I as measured by the perimeter air monitoring system was <0.01 percent of the inhalation concentration guide for individuals in uncontrolled areas (Table 5).

While some radioactivity was released to the atmosphere (Table 6), measurements in the Oak Ridge area show that environmental levels were well below established standards.

Nonradioactive - Environmental air samples are taken for the determination of fluorides, suspended particulates, and sulfur dioxide.

Sampling locations for fluorides are indicated by F-1 through F-6, Figure 1. The current sampling procedure is to obtain seven-day samples collected on potassium carbonate treated paper and to analyze weekly by specific ion electrode. These seven-day analyses are then averaged to obtain 30-day values.

Suspended particulates are measured at locations SP-1 through SP-4, Figure 1. The method for the determination of suspended particulates is the high volume method recommended by EPA. Particulates are collected by drawing air through weighed filter paper. The filter paper is allowed to equilibrate in a humidity controlled atmosphere and the filter is reweighed. From the weight of particulates, the sampling time, and the air flow rate, the particulate concentration in micrograms per cubic meter is calculated. The sampling period is 24 hours.

Two continuous monitoring stations (S-1 and S-2) were installed in the Y-12 Plant area for the measurement of ambient concentrations of sulfur dioxide. Each station consists of a flame photometric continuous analyzer and recorder with associated equipment located in a temperature controlled shelter. Sulfur dioxide concentrations are interpreted on an hourly basis and averaged for 24 hour, monthly, and annual periods.

Air monitoring data for fluorides, suspended particulates, and sulfur dioxide are presented in Table 7 through 9. These data indicate that average environmental concentrations of particulates and sulfur dioxide were in compliance with applicable standards[2] during calendar year 1978. Fluoride concentrations exceeded the standards on two occasions. However, the concentration of fluorides at Station F-6, which is five miles from Oak Ridge operations, indicates that the ambient fluoride background levels may be generally high in the area and makes interpretation of the incremental addition from Oak Ridge operations somewhat difficult.

Installation of electrostatic precipitators at the ORGDP steam plant was completed in 1978 and the Tennessee standards for particulate emissions from the steam plant stacks should be met. Acceptance testing of the precipitators for compliance with emission limits should be completed in early 1979.

The Y-12 steam plant is being upgraded to operate more efficiently at higher steam load levels. The current electrostatic precipitator installation is not adequate to meet emission limits at higher steam load levels. Funds have been requested for the installation of larger electrostatic precipitators to meet emission limits under higher operating load conditions.

External Gamma Radiation Monitoring

External gamma radiation background measurements are made routinely at eight of the perimeter air monitoring stations, at one station located near Melton Hill Dam, and at the remote monitoring stations using calcium fluoride thermoluminescent dosimeters suspended one meter above the ground. Dosimeters at the perimeter stations and Melton Hill Dam are collected and analyzed monthly. Those at the remote stations are collected and analyzed semiannually.

Data on the average external gamma radiation background are given in Table 10. The slight difference between the average levels in the perimeter and remote environs is considered to be within the variation in background levels normally experienced in East Tennessee which is dependent upon elevation, topography, and geological character of the surrounding soil.[3]

External gamma radiation measurements were performed along the stream course of East Fork Poplar Creek to evaluate radioactivity which might be contained in the sediments as a result of effluent releases. Additionally, measurements were made along the bank of the Clinch River from the mouth of White Oak Creek several hundred yards downstream to evaluate gamma radiation levels resulting from effluent releases and "sky shine" from an experimental ^{137}Cs plot located near the river bank. Measurements were made using scintillation detectors and/or thermoluminescent dosimeters suspended one meter above the ground surface. The average background level determined at the perimeter stations was subtracted from the measured gamma radiation levels to determine the incremental increases resulting from plant operations.

Gamma levels along East Fork Poplar Creek ranged from 0 to 11 μR/hr above background. The external gamma radiation levels along the bank of the Clinch River ranged from 1 to 27 μR/hr above background. Potential doses to individuals in the environment from these elevated gamma radiation levels were evaluated and are included, where significant, in the dose assessment section of the report.

Thermoluminescent dosimeters were also placed in 100 home residences in the Oak Ridge/Knoxville area in a special project performed over the period of October 1, 1977 through October 1, 1978. The average levels found were 78 and 84 mrem/yr in the Oak Ridge and Knoxville areas, respectively.

Water Monitoring

Radioactive - Water samples are collected in the Clinch River for radioactivity analyses at Melton Hill Dam (Station C-2) 3.7 kilometers above White Oak Creek outfall, at the ORGDP sanitary water intake (Station C-3) 10 kilometers downstream from the entry of White Oak Creek, at the ORGDP recirculating water intake (Station C-4) downstream from the Poplar Creek outfall, near Brashear Island (Station C-6), and at Center's Ferry (Station C-5) near Kingston, Tennessee, Figure 3. Samples are collected continuously at all locations except for Station C-5 and Station C-6 which are collected on a daily and monthly grab-sample basis, respectively. Samples are composited for monthly or quarterly analysis depending upon location.

Water samples also are collected for radioactivity analyses at White Oak Dam (Station W-1), at the outlet of New Hope Pond on East Fork Poplar Creek (Station E-1), in Bear Creek (Station B-1), and in Poplar Creek (Stations P-1 and P-2), Figure 3. The samples collected at Stations W-1, E-1, and B-1 are continuous proportional samples. Twenty-four hour composite samples are collected at Stations P-1 and P-2 on a weekly basis. Water samples were collected also at the juncture of White Oak Creek and the Clinch River. All samples are composited for monthly analysis.

The concentrations of fission product radionuclides present in detectably significant amounts are determined by specific radionuclide analysis and gamma spectrometry. Uranium analysis is by the fluorometric method. Transuranic alpha emitters are determined by ion exchange and alpha range analysis. The concentration of each radionuclide is compared with its respective concentration guide (CG) value as specified in the DOE Manual, Appendix 0524, and percent of concentration guide for a known mixture of radionuclides is calculated in accordance with the method given in Appendix 0524.

Data on the concentrations of radionuclides measured in the Clinch River are given in Table 11. Data on the concentrations of Uranium in surface streams and the quantities of radioactivity release to surface streams are given in Tables 12 and 13.

Analysis of water samples collected at the juncture of White Oak Creek and the Clinch River indicated that the yearly average concentration of radionuclides was approximately 16 percent of the applicable concentration guide for uncontrolled areas. The calculated average concentration of radionuclides in the Clinch River, based on the analysis of water samples collected at White Oak Dam (Station W-1) and the dilution afforded by the river, was determined to be 0.22 percent of the applicable concentration guide for uncontrolled areas assuming complete mixing. The measured average concentration of radionuclides in the Clinch River upstream and downstream of White Oak Creek outfall were less than 0.2 percent of the applicable concentration guide.

The calculated average concentration of transuranic alpha emitters in the Clinch River resulting from effluent releases was 8×10^{-12} μCi/ml, which is less than 0.01 percent of the concentration guide for water containing a known mixture of radionuclides.

Trends in water discharges and calculated percent concentration guide levels in the Clinch River are presented in Figures 4 and 5. Discharges of ^{90}Sr and ^{3}H are shown in Figure 4 as these nuclides contribute the majority of the radiological dose downstream.

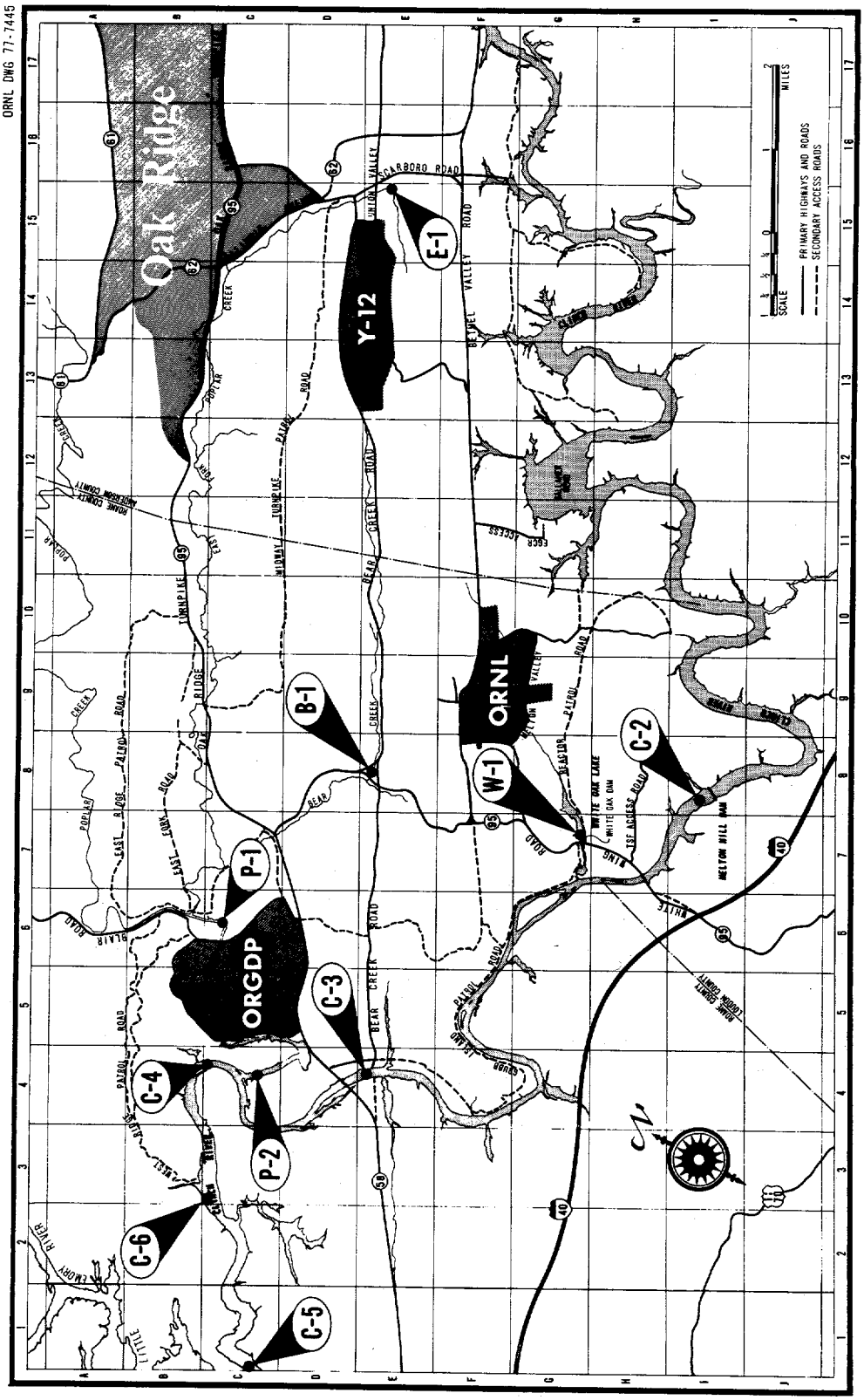

Figure 3
STREAM MONITORING LOCATIONS

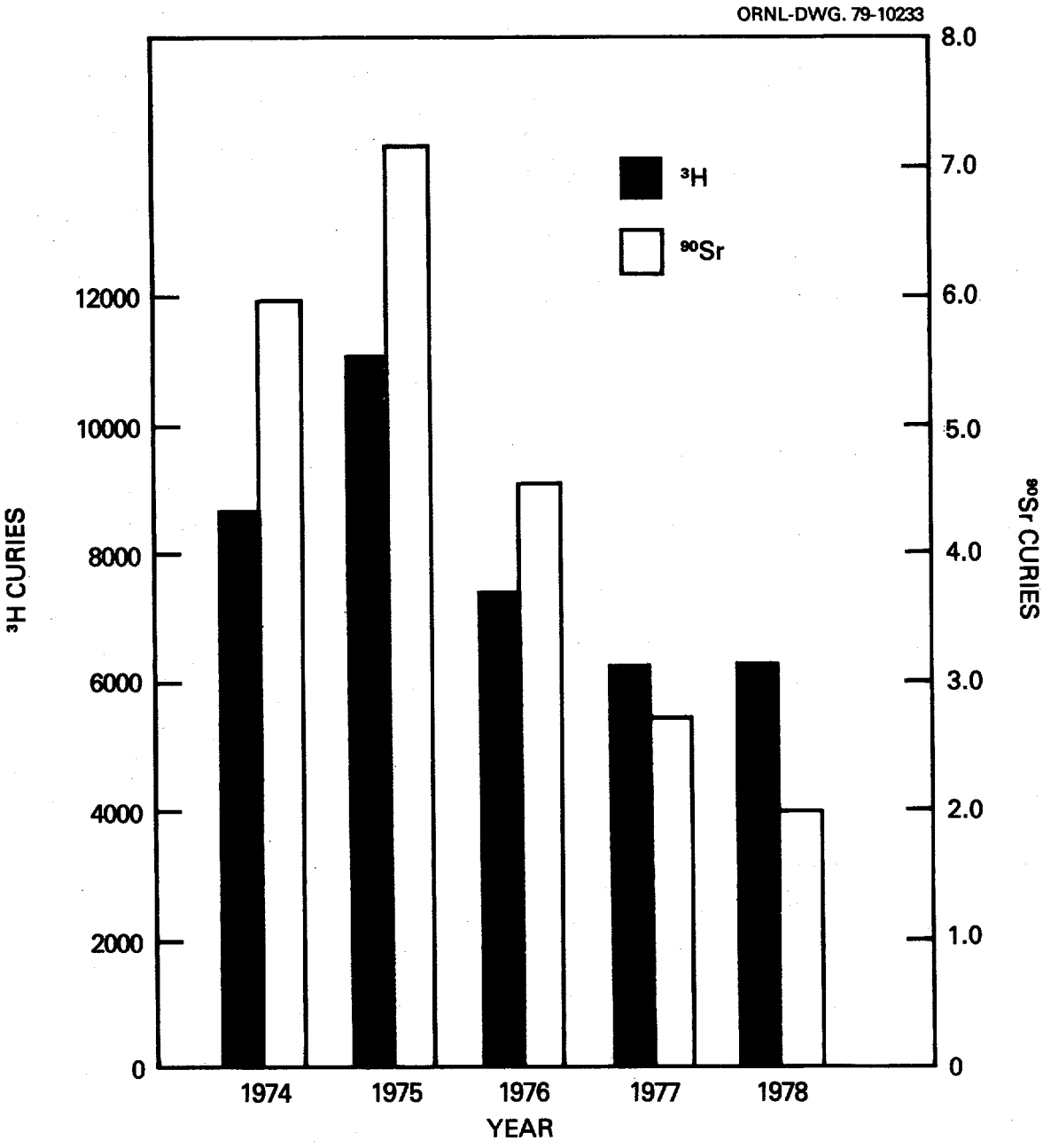

Figure 4
CURIES DISCHARGED OVER WHITE OAK DAM

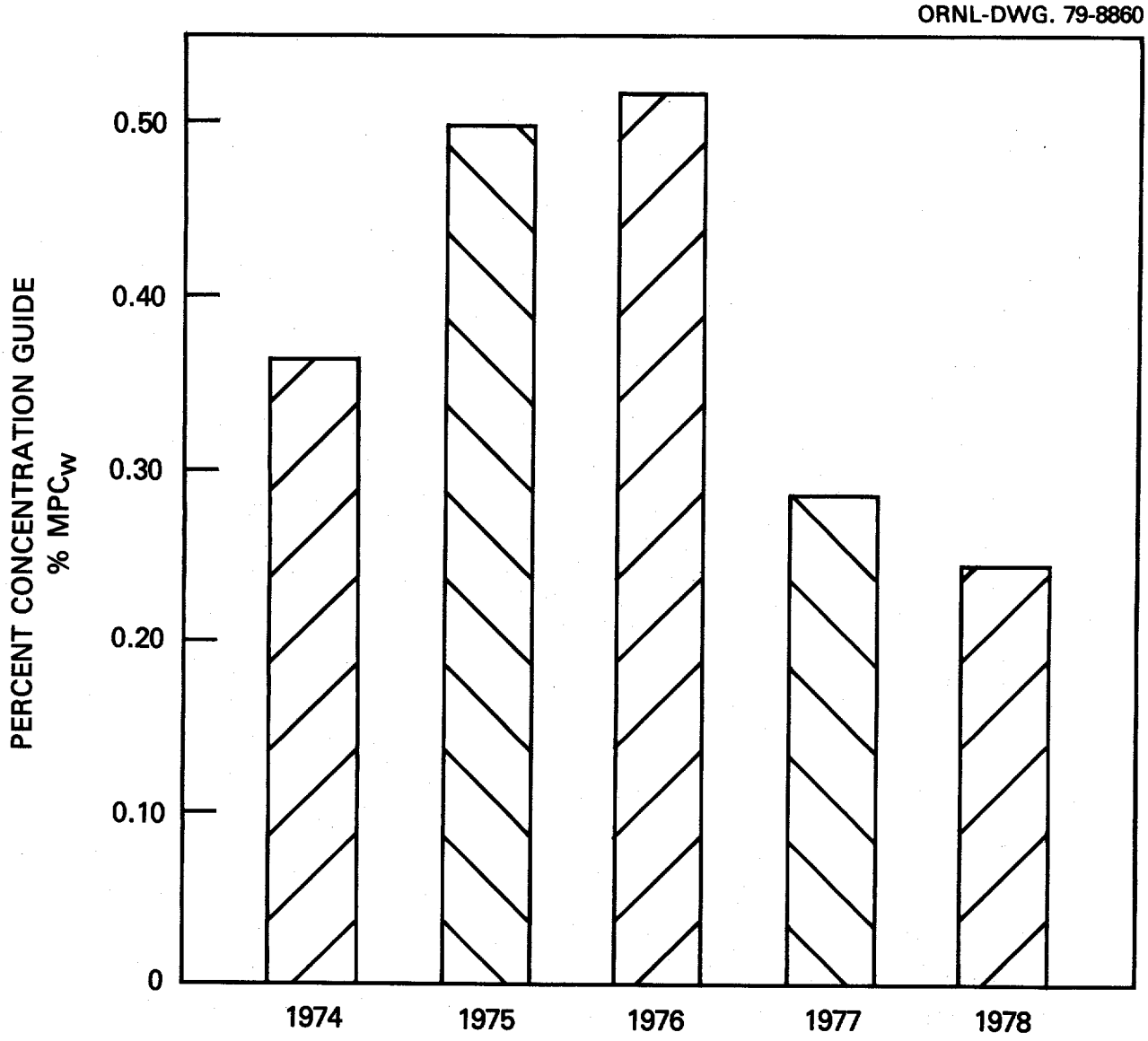

Figure 5

PERCENT CONCENTRATION GUIDE LEVELS IN THE CLINCH RIVER
(VALUES GIVEN ARE CALCULATED VALUES BASED ON THOSE CONCENTRATIONS MEASURED AT WHITE OAK DAM AND DILUTION AFFORDED BY THE CLINCH RIVER.)

Rainwater - The gross beta activity in rainwater was analyzed; the results are shown in Table 14. The fluctuations among the stations for both the perimeter and remote networks are due to statistical random variation. It is noted that the average radioactivity is greater for the remote stations than the perimeter stations.

Nonradioactive - Water samples are collected for the analysis of nonradioactive substances at the same locations discussed previously under radioactive water sampling. All samples are composited for monthly analysis. Samples are analysed for a variety of water quality parameters related to process release potential and background information needs by analytical procedures recommended by the Environmental Protection Agency.[4]

Data on chemical concentrations in surface streams are given in Tables 15 through 23. The average concentrations of all substances analyzed were in compliance with Tennessee stream guidelines[5] except for fluorides at Station E-1 which was 110 percent of the guidelines (the primary source of fluorides is fluoridated water from the Oak Ridge water treatment plant).

Dissolved oxygen (DO) and pH measurements are made continuously at White Oak Dam (Station W-1). Measurements of dissolved oxygen and pH at White Oak Dam indicated DO values ranging from 4 to >15 mg/l and pH values from 6.3 to 9.7. The dissolved oxygen was out of compliance with the State standard[6] on 12 occasions and the pH was out of compliance with the State standard on 166 separate occasions. Noncompliance of DO and pH at White Oak Dam was attributed to natural causes.

National Pollutant Discharge Elimination System (NPDES) permits were issued by the Environmental Protection Agency (EPA) for each of the Oak Ridge facilities operated by Union Carbide Corporation - Nuclear Division in 1975. The permits established a number of discharge locations at each installation and listed specific concentration limits and/or monitoring requirements for a number of parameters at each discharge location. Table 24 contains the discharge locations at each installation, the parameters at each location for which limits have been established, the permit limits for each parameter, and the percentage compliance experienced.

Biological Monitoring

Milk - Raw milk is monitored for ^{131}I and ^{90}Sr by the collection and analysis of samples from 13 sampling stations located within a radius of 80 kilometers of Oak Ridge. Samples are normally collected weekly at each of eight stations located near the Oak Ridge area. Five stations, located more remotely with respect to Oak Ridge operations, are sampled at a rate of one station each week. Milk sampling locations for all stations are shown in Figures 6 and 7. Samples are analyzed by ion exchange and gamma spectrometry; results are compared to intake guides specified by the Federal Radiation Council (FRC).[7]

The average concentrations of ^{131}I and ^{90}Sr in raw milk are given in Tables 25 and 26, respectively. If one assumes the average intake of milk per individual to be one liter per day, the average concentration of ^{131}I in the milk in both the immediate environs of the Oak Ridge area and in the environs remote from Oak Ridge were within FRC Range I.

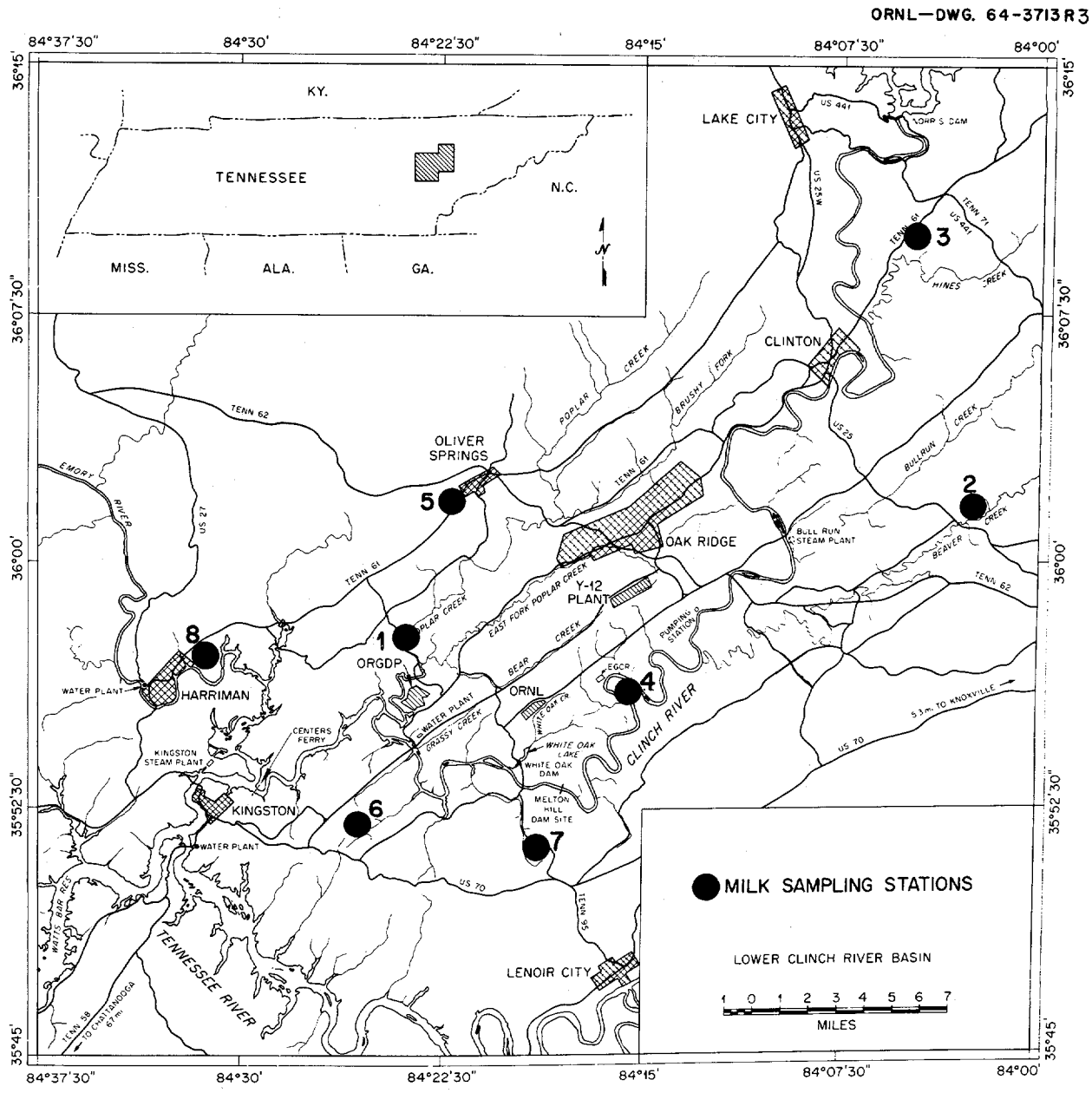

Figure 6
IMMEDIATE ENVIRONS MILK SAMPLING LOCATIONS

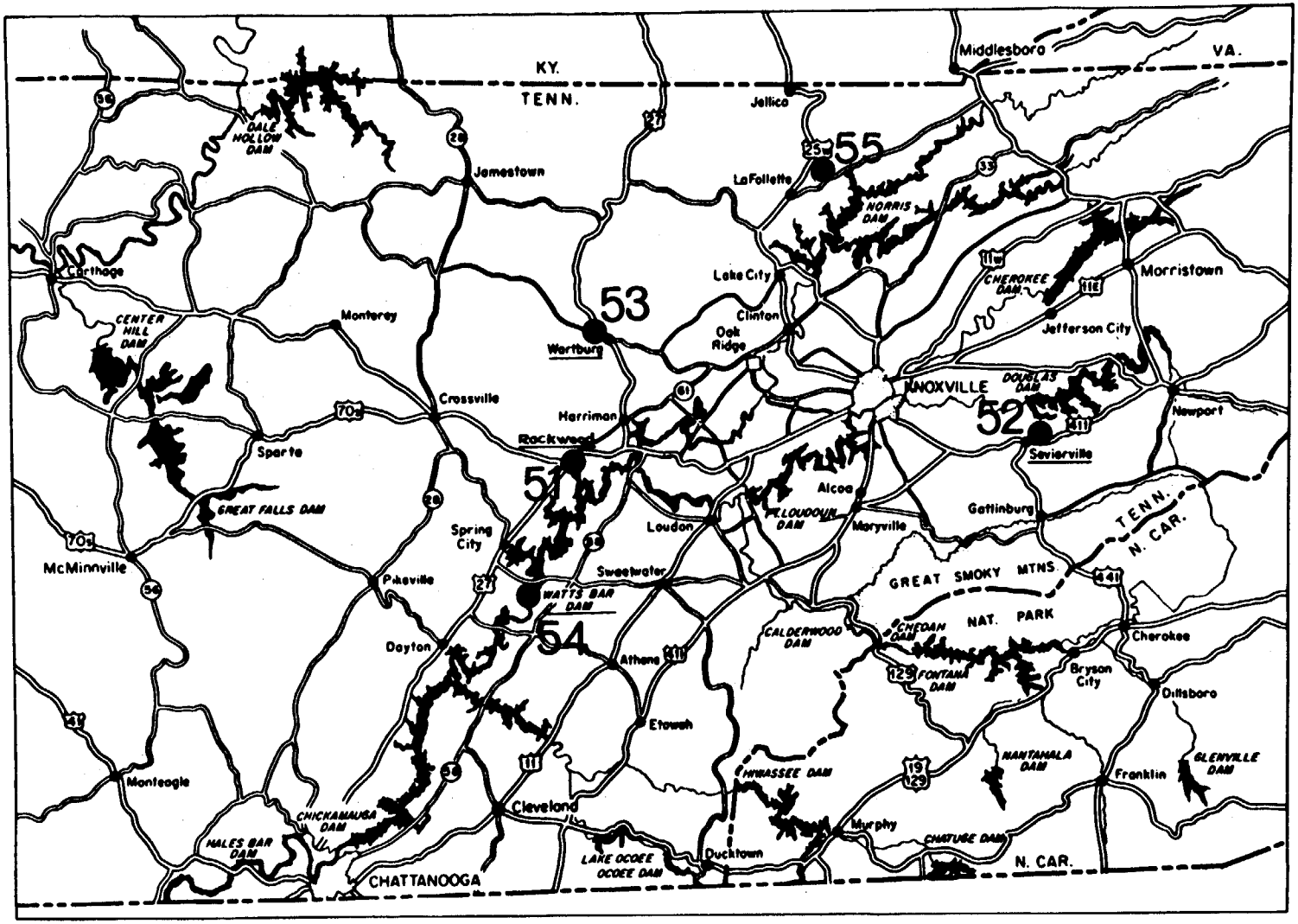

Figure 7
REMOTE ENVIRONS MILK SAMPLING LOCATIONS

The average concentrations of ^{90}Sr in milk from both the immediate and remote environs were within the FRC Range I. The concentration of ^{90}Sr in milk is different at different locations; part of the variation has been found to result from differences in farming methods used at different farms. Pastureland that is not fertilized and is overgrazed (a not too uncommon practice in this area) apparently results in a higher than normal concentration of ^{90}Sr in milk from cows pastured on this land.

Fish Sampling - Several species of fish which are commonly caught are taken from the Clinch River during the spring and summer of each year. The scales, head, and entrails are removed from the fish before ashing. Ten fish of each species are composited for each sample, and the samples are analyzed by gamma spectrometry and radiochemical techniques for the critical radionuclides which may contribute significantly to the potential radiation dose to man.

Data on the concentrations of radionuclides in Clinch River fish are given in Table 27. Consumption of 16.8 kilograms of bluegill per year[8] taken from the river near White Oak Creek outfall results in approximately 2 percent of the maximum permissible intake, which represents the highest dose potential to the public from fish consumption. The maximum permissible intake is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing the concentration guide of the radionuclides in question. Mercury concentrations in the fish samples collected were all much less than the FDA proposed action level.

Deer - Occasionally, deer are killed by automobiles on the DOE Reservation. Five road-killed deer samples were analyzed during 1978 for gamma emitters, and the data is presented in Table 28. The deer with the highest amount of ^{137}Cs would result in a dose of .002 mrem to the total body and .006 mrem to the liver (critical organ). It should be noted that no hunting is allowed on the Oak Ridge Reservation.

Vegetation - Samples of pine needles and grass are collected semiannually from 17 areas (Stations VS-1 through VS-17, Figure 1) and analyzed for uranium and fluoride content. Fluorometric analysis is used for the determination of uranium and colorimetric analysis is used for the determination of fluorides.

Data on the uranium and fluoride content in vegetation are presented in Table 29. The fluoride concentration in grass at all sampling points was below the 30 ppm level considered to produce no adverse effects when ingested by cattle.[9] Uranium concentrations were below levels of environmental concern.

Additionally, samples of grass were collected semiannually from the perimeter and annually from the remote air-sampling stations (see Figures 1 and 2). At each station, all the grass from five 1/5-meter-squared plots was collected. One plot was taken beside the station, and the other four were taken at 15 m from the station at 90° directions from each other. The grass from each station was then composited and analyzed by gamma spectrometry and radiochemical techniques for a variety of radionuclides. Data on the radionuclide concentrations in grass are presented in Table 30.

Honey Samples - Honey samples from two hives located on the reservation were analyzed for radioactivity. Only trace amounts were found of ^{3}H and ^{137}Cs.

Soil and Sediment Monitoring

Soil - Soil samples are also collected semiannually from near the perimeter and annually from the remote stations. The same five 1/5 meter-squared plots used for grass analysis were also used for soil determinations. Two cores, 8 cm in diameter and 5 cm in depth, were taken from each plot; a composite of 10 cores was used for each station. These samples were also analyzed by gamma spectrometry and radio-chemical techniques.

A distribution plot of uranium in soils at the various perimeter stations in shown in Figures 8 and 9. For a distribution plot, the concentration at each station is plotted versus its ranking in the distribution. Using this type of plot, it can readily be seen whether the data belong to the same or different statistical populations. It is shown in Figure 8 that for ^{234}U in perimeter soils that station 32 belongs to a higher distribution than the other stations. For ^{235}U content, station 32 belongs to the same distribution, although it has the highest value, see Figure 9. Station 32 is close to and directly northeast (dominant wind direction) of the Y-12 plant.

Data on specific radionuclide concentrations in soil are given in Table 31. The plutonium concentrations found were comparable to the value of 0.05 pCi/g considered to be a representative concentration of plutonium in U.S. surface soil.[10]

Sediment - A sediment sampling program was initiated at ORGDP in 1975 to determine the concentrations of various metallic ions in the sediment of Poplar Creek. During 1977, this sampling program had expanded to 20 locations, including two sampling locations on the Clinch River and one sampling location on East Fork Poplar Creek. A review of the sediment sampling program resulted in the deletion of eight sampling locations and the addition of two new sampling locations. The current sampling locations provide for sediment samples which should be generally representative of plant effluents while reducing the clustered distribution of locations used in the previous sampling scheme. The 14 sediment sampling locations are shown in Figure 10. Samples are collected twice during the year and analyzed by atomic absorption.

The concentrations of metals in the stream sediment samples, Table 32, generally exceed background levels for metals in remote steams, except for cadmium and thorium which were below detectable limits. An examination of the effluent sources indicates that only very small quantities of any of these metals are currently being released, suggesting that present concentrations found in sediment samples are residual metals from earlier plant operations.

Calculation of Potential Radiation Dose to the Public

Potential radiation doses resulting from plant effluents were calculated for a number of dose reference points within the Oak Ridge environs. All significant sources and modes of exposure were examined, and a number of general assumptions were used in making the calculations.

The site boundary for the Oak Ridge complex was defined as the perimeter of the DOE controlled area.

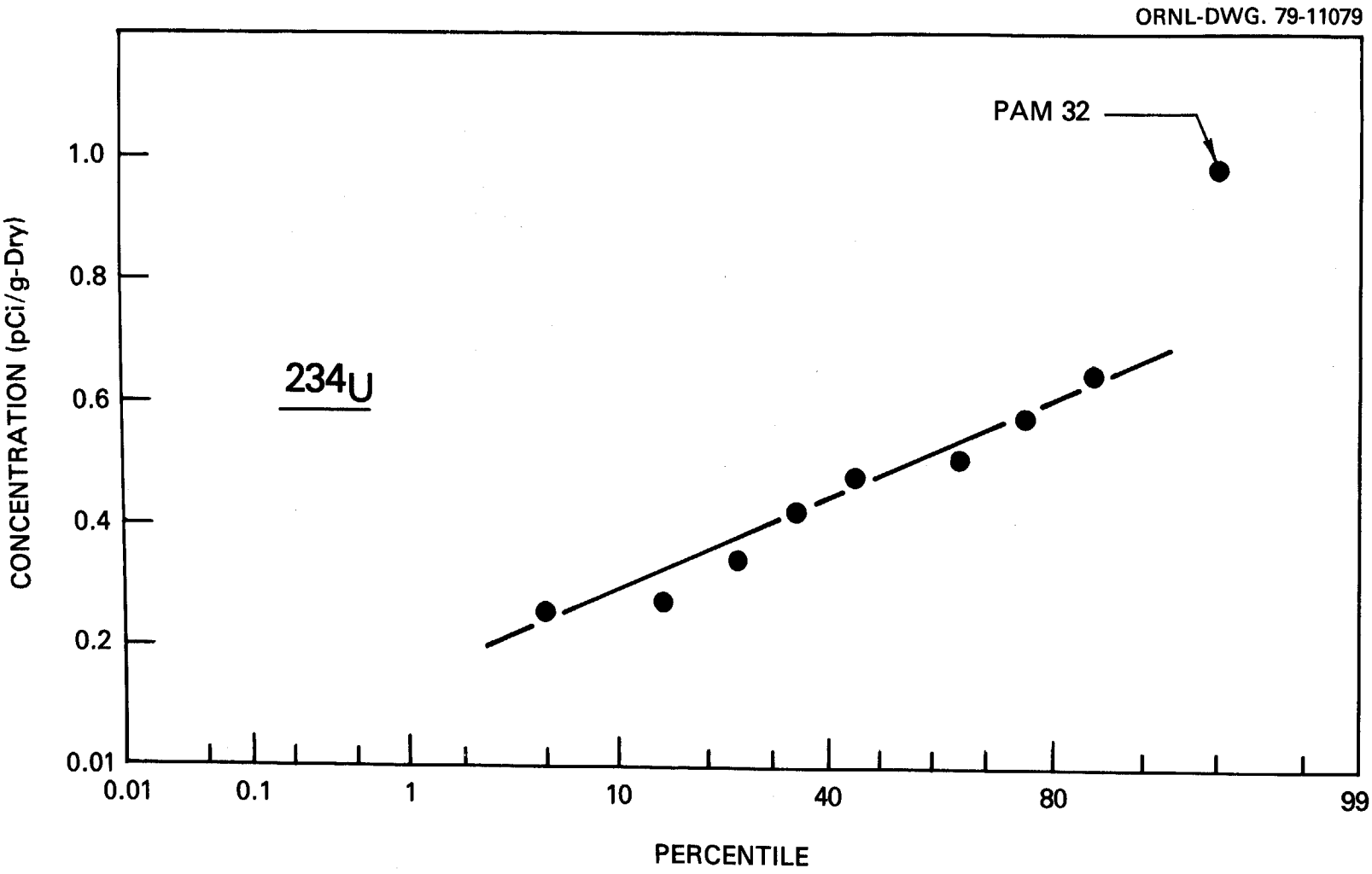

Figure 8

DISTRIBUTION PLOT OF URANIUM-234 IN SOIL

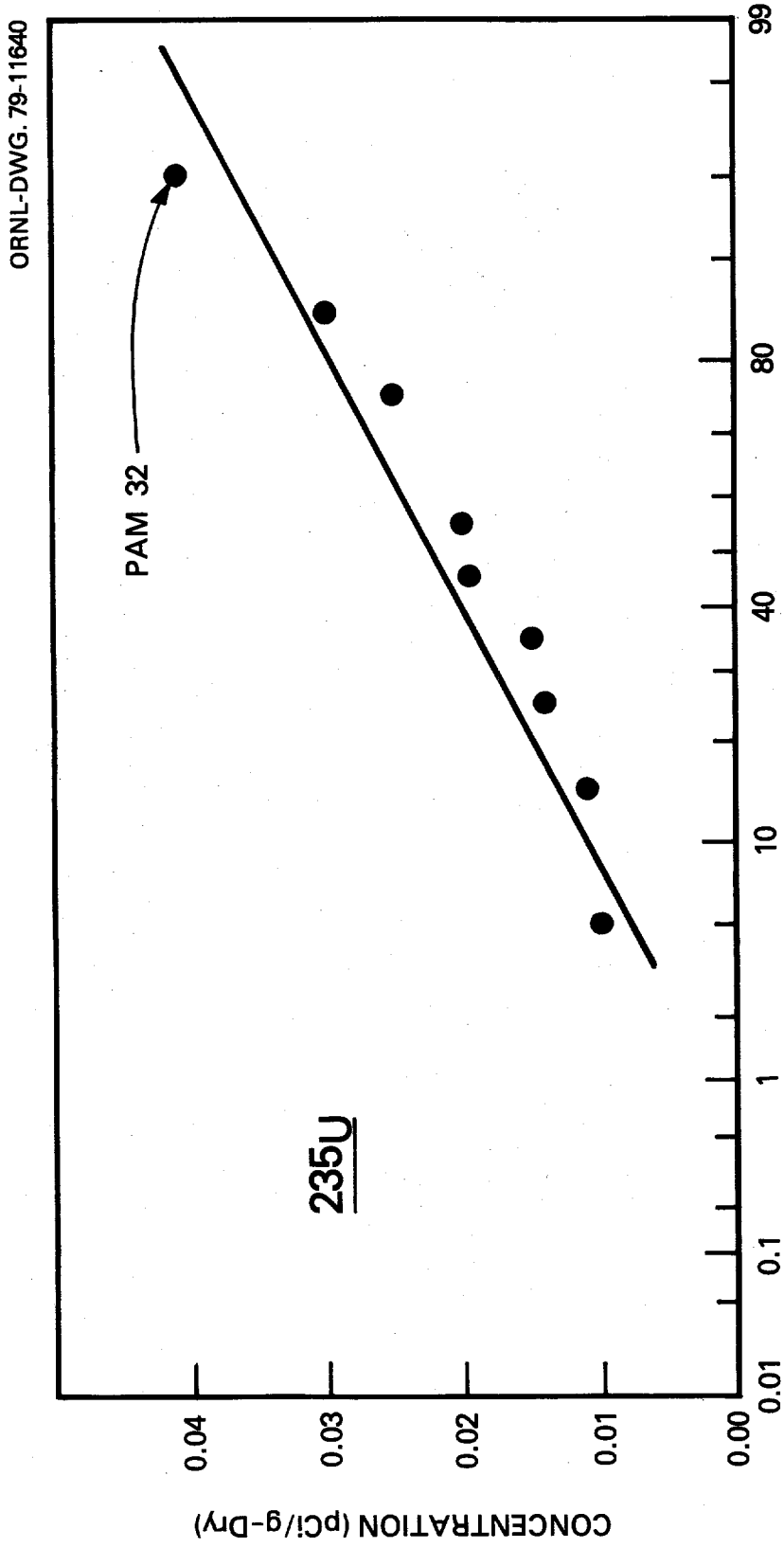

Figure 9
DISTRIBUTION PLOT OF URANIUM-235 IN SOIL

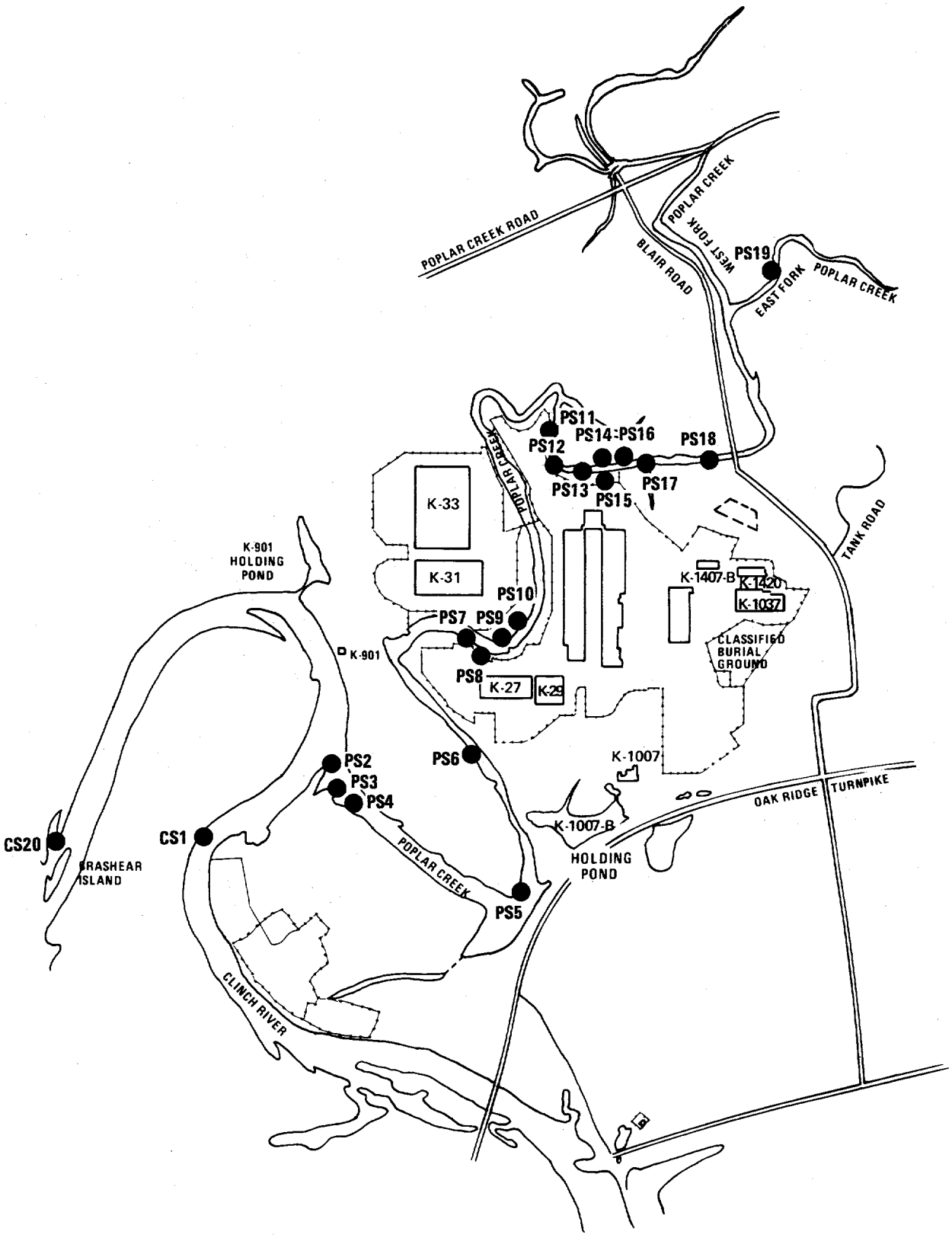

Figure 10
OAK RIDGE GASEOUS DIFFUSION PLANT SEDIMENT SAMPLING LOCATIONS

Gaseous effluents are discharged from several locations within each of the three Oak Ridge facilities. For calculational purposes, the gaseous discharges are assumed to occur from only one vent from each site. Since the release points at ORGDP and the Y-12 Plant do not physically approximate an elevated stack, their discharges are assumed to be from 10 meters above ground level; releases from ORNL are through elevated stacks. The meteorological data collected at the ORNL site were used for dispersion calculations. Concentrations of radionuclides contained in the air and deposited on the ground were estimated at distances up to 80 kilometers from the Oak Ridge facilities with the Gaussian plume model developed by Pasquill[11] and Gifford[12] incorporated in a computer program.[13] The concentration has been averaged over the crosswind direction to give the estimated ground level concentration downwind of the source of emission.[14] The deposition velocities used in the calculations were 10^{-6} cm/sec for krypton and xenon, 10^{-2} cm/sec for iodine, and 1 cm/sec for particulates.[15] Meteorological data is shown in Figure 11; the length of the bars indicates the percentage of time the wind is blowing in that direction.

Potential pathways of exposure to man from radioactive effluents released by the Oak Ridge operations that are considered in the dose estimates are presented in Figure 12. The pathways shown in the figure are not exhaustive, but they include the principal pathways of exposure based on experience.

Exposures to radionuclides that originate in the effluents released from the Oak Ridge facilities were converted to estimates of radiation dose to individuals using models and data presented in publications of the International Commission on Radiological Protection,[16-21] other recognized literature on radiation protection,[22-24] personal communication,[25] and computer programs incorporating some of these models and data.[26,27] Radioactive material taken into the body by inhalation or ingestion will continuously irradiate the body until removed by processes of metabolism and radioactive decay; thus the estimates for internal dose are called "dose commitments;" they are obtained by integrating over the assumed remaining lifetime (50 years) of the exposed individual.

The radiation doses to the total body and to internal organs from external exposures to penetrating radiation are approximately equal, but they may vary considerably for internal exposures because some radionuclides concentrate in certain organs of the body. For this reason, estimates or radiation dose to the total body, thyroid, lungs, bone, liver, kidneys, and gastrointestinal tract were considered for various pathways of exposure. These estimates were based on parameters applicable to an average adult.[16,21] The population dose estimate (in man-rem) is the sum of the total body doses to exposed individuals within an 80-kilometer radius of the Oak Ridge facilities.

Maximum Potential Exposure - The point of maximum potential exposure ("fence-post" dose) on the site boundary is located along the bank of the Clinch River adjacent to a cesium field experimental plot and is due primarily to "sky-shine" from the plot. A maximum potential total body exposure 243 mrem/yr was calculated for this location assuming that an individual remained at this point for 24 hours/day for the entire year. The calculated maximum potential exposure is 49 percent of the allowable standard.[1] This is an atypical exposure location and the probability of an exposure of the magnitude calculated is considered remote since access is only by boat.

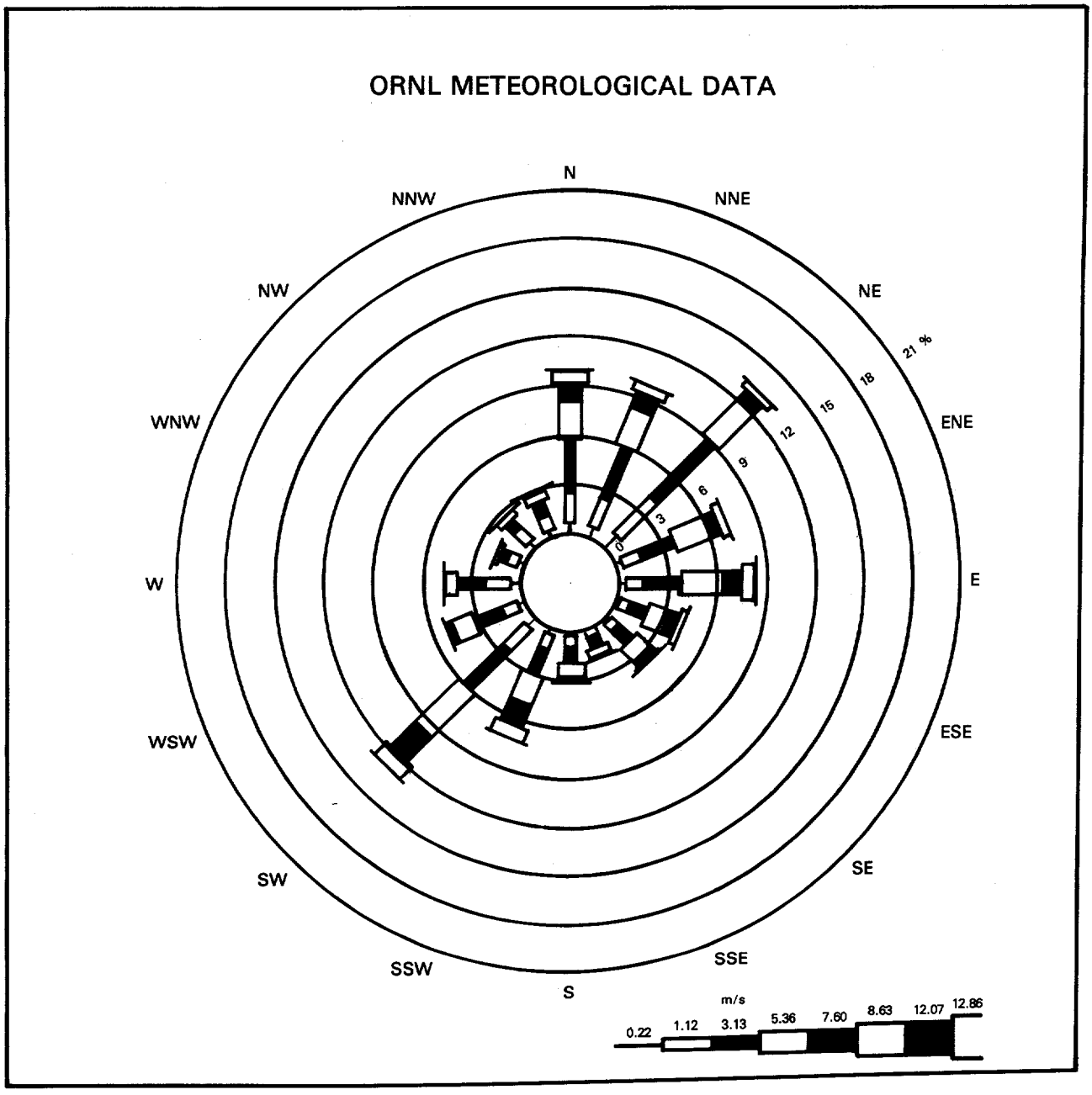

Figure 11
METEOROLOGICAL DATA FOR THE OAK RIDGE RESERVATION

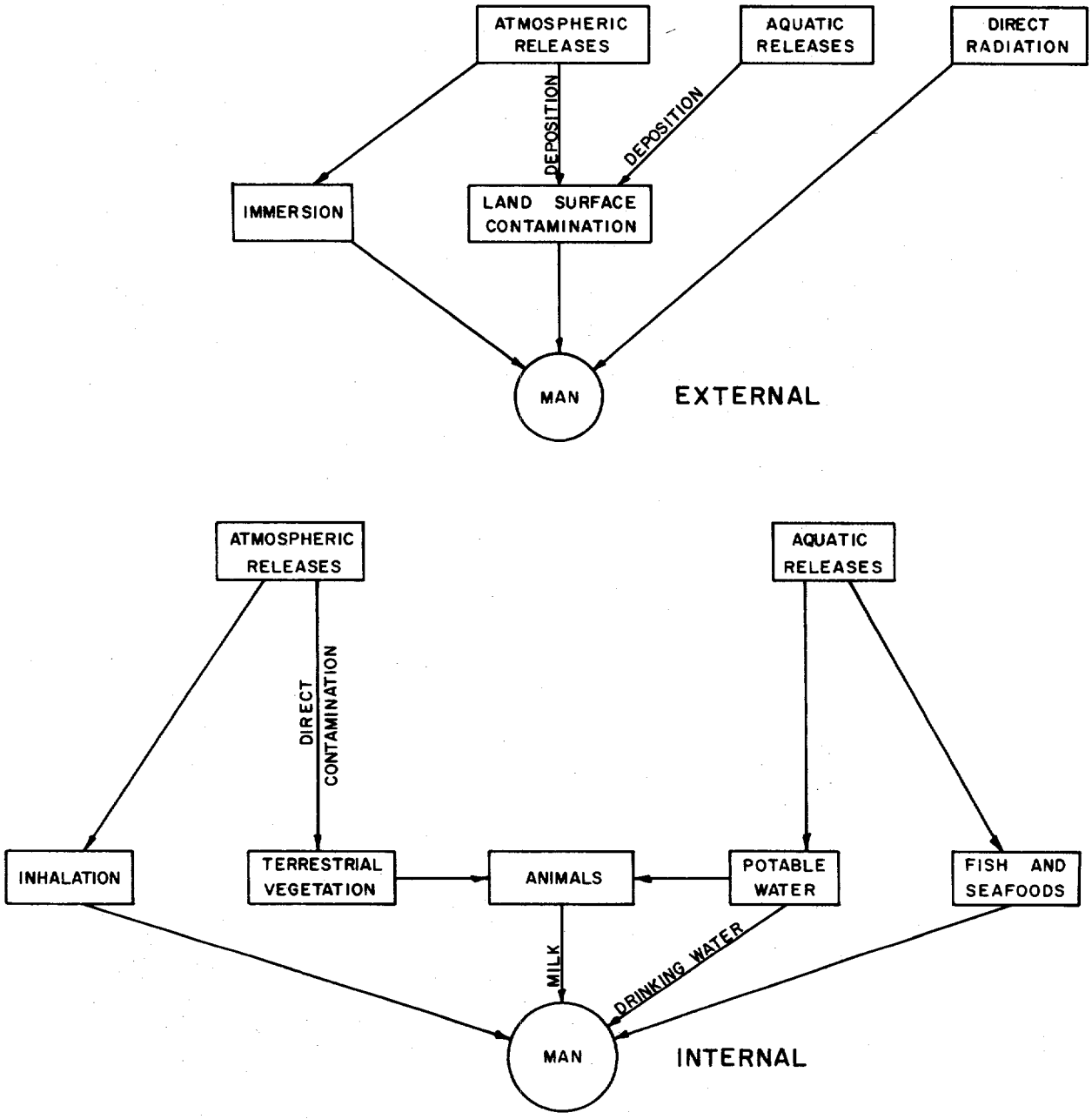

Figure 12
EXPOSURE PATHWAYS

The total body dose to a "hypothetical maximum exposed individual" at the same location was calculated using a more realistic residence time of 240 hours/yr. The calculated dose under these conditions was 6.7 mrem/yr which is 1.3 percent of the allowable standard[1] and represents what is considered a probable upper limit of exposure.

A more probable exposure potential might be considered to occur at other locations beyond the site boundary as a result of airborne or liquid effluent releases.

The dose commitment to an individual continuously occupying the residence nearest the site boundary would result from inhalation and is based on an inhalation rate for the average adult of 2×10^4 liters/day. The calculated dose commitments at this location were 1.0 ± 150% millirem to the lung (the critical organ) and 0.14 ± 150% millirem to the total body; uranium-234 is the important radionuclide contributing to this dose. These levels are 0.07 percent and 0.03 percent, respectively, of the allowable annual standard. The large error bounds are due to the uncertainties in the meteorological data.[28]

The most important contribution to dose from radioactivity within the food-chain is by the atmosphere-pasture-cow-milk food-chain pathway. Measurements of the two principal radionuclides entering into this pathway, ^{131}I and ^{90}Sr (see Table 25 and 26), indicate that the maximum dose to an individual in the immediate environs from ingestion of one liter of milk per day is 0.5 mrem to the thyroid and 10.3 mrem to the bone at Station 6. The average concentrations for the remote stations were assumed to be background and were subtracted from the perimeter station data in making the calculations.

The public water supply closest to the liquid discharges from the Oak Ridge facilities is located approximately 26 kilometers downstream at Kingston, Tennessee. The intake to the water filtration plant is located on the Tennessee River approximately one-half mile upstream from the confluence of the Clinch and Tennessee Rivers. Normally, Tennessee River water is used for the Kingston water supply but under certain conditions of power generation, backflow can occur. Under backflow conditions, Clinch River water may move upstream in the Tennessee River and be used as the source of water for the Kingston filtration plant. It is estimated that these conditions would prevail a maximum of 20 percent of the time. Measurements of untreated river water samples at Kingston (see Table 11) indicate that the maximum dose commitment resulting from the ingestion of 20 percent of the daily adult requirement (about two liters per day) is 0.12 millirem to the bone; ^{90}Sr present in the waters upstream of the Oak Ridge facilities accounts for 90 percent (0.11 millirem) of this dose. The resulting 0.01 millirem is about 0.0007 percent of the annual standard.

Estimates of the 50-year dose commitment to an adult were calculated for consumption of 16.8 kilograms of fish per year from the Clinch River. The consumption of 16.8 kilograms[8] is about 2.5 times the national average fish consumption[29] and is used because of the popularity of fishing in East Tennessee. From the analysis of edible parts of the fish examined (see Table 27), the maximum organ dose commitment to an indivdual from the bluegill samples taken from CRM 20.8 is estimated to be 23.7 millirem to the bone from ^{90}Sr. The maximum total body dose to an individual was calculated to be 13.6 millirem from the bass samples collected at the same location; this fish would also result in a liver dose of 34.5 mrem from ^{137}Cs. These doses from the bass for whole body and liver are 2.7 percent and 2.3 percent, respectively, of the allowable annual standard. Fish samples taken from above White Oak Creek were analyzed to determine background conditions.

Summaries are given in Table 33 of the potential radiation doses to adult members of the general public at the points of highest potential exposure from gaseous and liquid effluents from the Oak Ridge facilities.

Dose to the Population - The Oak Ridge population received the largest average individual total body dose as a population group. The average total body dose to an Oak Ridge resident was estimated to be 0.05 ± 150% millirem as compared to approximately 100 mrem/yr from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 0.2 ± 150% millirem. The maximum potential dose commitment to an Oak Ridge resident was calculated to be 1.0 ± 150% millirem to the lung. This calculated dose is 0.07 percent of the allowable annual standard.[1]

The cumulative total body dose to the population within an 80 kilometer radius of the Oak Ridge facilities resulting from 1978 plant effluents was calculated to be 5.6 ± 150% man-rem. This cumulative dose was calculated using the population distribution given in Table 1 for ORNL atmospheric effluents; similar population distributions were used for the Y-12 and ORGDP releases. This dose may be compared to an estimated 74,000 man-rem to the same population resulting from natural background radiation. About 26 percent of the collective dose from the effluents of the Oak Ridge facilities is estimated to be to the Oak Ridge population.

Table 1

INCREMENTAL POPULATION TABLE IN THE VICINITY OF ORNL

DISTANCE, MILES DISTANCE, KM	0-1 0-1.6	1-2 1.6-3.2	2-3 3.2-4.8	3-4 4.8-6.4	4-5 6.4-8.0	5-10 8-16	10-20 16-32	20-30 32-48	30-40 48-64	40-50 64-80
Direction										
E	0	0	0	0	0	3,059	44,880	100,500	11,790	12,390
ENE	0	0	0	0	0	0	27,460	74,690	18,720	13,870
NE	0	0	0	0	0	9,713	12,480	7,167	4,392	7,476
NNE	0	0	0	0	1,461	13,780	4,362	11,190	12,670	6,119
N	0	0	0	0	1,490	5,578	2,177	1,441	2,223	4,508
NNW	0	0	0	0	0	1,495	0	1,152	4,559	4,676
NW	0	0	0	0	0	1,073	4,804	1,538	1,896	7,552
WNW	0	0	0	0	0	587	2,971	1,543	0	4,151
W	0	0	0	0	0	666	13,100	4,595	9,038	7,318
WSW	0	0	0	0	0	622	9,862	3,495	4,562	4,204
SW	0	0	0	0	0	733	1,840	1,909	3,962	8,578
SSW	0	0	0	0	0	721	2,055	7,897	21,580	10,530
S	0	0	0	0	0	943	8,742	7,309	6,560	1,222
SSE	0	0	0	0	1,374	7,277	1,290	4,091	469	0
SE	0	0	0	0	0	1,167	4,304	15,010	46	0
ESE	0	0	0	0	0	6,096	5,343	36,020	4,132	6,840
TOTAL	0	0	0	0	4,325	53,510	145,670	279,547	106,599	99,434
CUMULATIVE TOTAL	0	0	0	0	4,325	57,835	203,505	483,052	589,651	689,085

Table 2
CONTINUOUS AIR MONITORING DATA
Long-Lived Gross Beta Activity of Particulates in Air
1978

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-13} μCi/ml			%
			MAXIMUM[a]	MINIMUM[b]	AVERAGE	CG[c]
		Perimeter Area[d]				
HP-31	Kerr Hollow Gate	52	1.3	0.12	0.48 ± 0.08	0.05
HP-32	Midway Gate	51	10.4	0.18	0.83 ± 0.40	0.08
HP-33	Gallaher Gate	51	6.4	0.02	0.56 ± 0.24	0.06
HP-34	White Oak Dam	52	10.9	0.17	0.84 ± 0.42	0.08
HP-35	Blair Gate	51	1.6	0.01	0.59 ± 0.12	0.06
HP-36	Turnpike Gate	52	9.0	0.09	0.68 ± 0.34	0.07
HP-37	Hickory Creek Bend	52	8.0	0.09	0.61 ± 0.30	0.06
HP-38	East of EGCR	50	10.1	0.08	0.78 ± 0.39	0.08
HP-39	Townsite	52	10.8	0.17	0.79 ± 0.40	0.08
Average					0.68 ± 0.11	0.07
		Remote Area[e]				
HP-51	Norris Dam	52	10.2	0.08	0.78 ± 0.38	0.08
HP-52	Loudoun Dam	50	12.1	0.10	0.80 ± 0.48	0.08
HP-53	Douglas Dam	52	11.3	0.08	0.75 ± 0.42	0.08
HP-54	Cherokee Dam	52	11.9	0.08	0.75 ± 0.44	0.08
HP-55	Watts Bar Dam	52	15.0	0.01	0.57 ± 0.58	0.06
HP-56	Great Falls Dam	50	13.7	0.04	0.80 ± 0.53	0.08
HP-57	Dale Hollow Dam	52	12.3	0.04	0.92 ± 0.46	0.09
HP-58	Knoxville	52	10.5	0.01	0.67 ± 0.40	0.07
Average					0.75 ± 0.16	0.08

[a]Maximum weekly average concentration.

[b]Minimum weekly average concentration–minimum detectable level is 3×10^{-6} μCi per sample.

[c]CG is 10^{-10} μCi/ml for unidentified radionuclides (DOE Manual, Appendix 0524, Annex A, Table II).

[d]See Figure 1.

[e]See Figure 2.

Table 3
CONTINUOUS AIR MONITORING DATA
Long-Lived Gross Alpha Activity of Particulates in Air
1978

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-15} μCi/ml			% CG[c]
			MAXIMUM[a]	MINIMUM[b]	AVERAGE	
		Perimeter Area[d]				
HP-31	Kerr Hollow Gate	52	2.9	0.5	1.1 ± 0.2	0.03
HP-32	Midway Gate	51	4.1	0.7	1.4 ± 0.2	0.04
HP-33	Gallaher Gate	51	3.7	0.5	1.1 ± 0.2	0.03
HP-34	White Oak Dam	52	3.1	0.5	1.0 ± 0.2	0.03
HP-35	Blair Gate	51	40.9	<0.1	<2.2 ± 0.2	<0.06
HP-36	Turnpike Gate	52	4.2	0.5	1.1 ± 0.2	0.03
HP-37	Hickory Creek Bend	52	2.9	0.3	0.9 ± 0.2	0.02
HP-38	East of EGCR	50	3.5	0.5	1.1 ± 0.2	0.03
HP-39	Townsite	52	3.4	0.6	1.1 ± 0.2	0.03
Average					<1.2 ± 0.1	<0.03
		Remote Area[e]				
HP-51	Norris Dam	52	1.8	0.5	0.9 ± 0.1	0.02
HP-52	Loudoun Dam	50	1.8	0.5	0.8 ± 0.1	0.02
HP-53	Douglas Dam	52	3.3	0.5	1.2 ± 0.2	0.03
HP-54	Cherokee Dam	52	2.3	<0.1	<0.9 ± 0.1	<0.02
HP-55	Watts Bar Dam	52	3.8	<0.1	<0.9 ± 0.2	<0.02
HP-56	Great Falls Dam	52	3.5	0.5	0.9 ± 0.2	0.02
HP-57	Dale Hollow Dam	52	2.5	0.5	1.0 ± 0.1	0.03
HP-58	Knoxville	52	2.8	0.5	1.0 ± 0.2	0.06
Average					<1.0 ± 0.1	<0.03

[a]Maximum weekly average concentration.

[b]Minimum weekly average concentration-minimum detectable level is 2×10^{-6} μCi per sample.

[c]CG is 40×10^{-13} μCi/ml for a mixture of uranium isotopes. (DOE Manual, Appendix 0524, Annex A, Table II).

[d]See Figure 1.

[e]See Figure 2.

Table 4
CONTINUOUS AIR-MONITORING DATA
Specific Radionuclides in Air
(Composite Samples)
1978
Units of 10^{-15} μCi/ml

RADIONUCLIDE	PERIMETER STATIONS					REMOTE STATIONS				
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Yearly Average	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Yearly Average
^{7}Be	110	120	103	92.5	106	115	125	89.3	73.5	100.7
^{54}Mn	0.20	0.26	0.051	0.025	0.13	0.17	0.29	ND	0.025	0.16
^{90}Sr	1.49	1.25	0.27	0.21	0.81	1.6	0.85	0.44	0.22	0.78
^{95}Zr	6.9	1.7	0.25	ND*	2.95	7.4	1.9	0.20	ND	3.2
^{95}Nb	16.7	10.2	0.86	ND	9.25	17.6	10.5	0.71	0.15	7.24
^{103}Ru	47.3	ND	ND	ND	47.3	51.7	1.2	ND	ND	26.5
^{106}Ru	14.8	17.3	4.9	1.8	9.7	15.3	18.1	4.4	1.75	9.89
^{125}Sb	2.2	2.7	0.81	0.25	1.49	2.0	2.8	0.71	0.25	1.44
^{137}Cs	2.7	4.0	1.32	0.55	2.14	2.8	4.2	1.2	0.48	2.17
^{141}Ce	36.9	0.51	ND	0.5	12.6	39.8	ND	ND	0.35	20.1
^{144}Ce	23.2	29.1	7.6	2.35	15.6	23.9	31.6	7.1	2.2	16.2
^{228}Th	< 0.0027	0.013	0.012	0.012	< 0.0093	< 0.0051	0.0047	0.014	0.012	< 0.0089
^{230}Th	0.0044	0.12	0.012	0.010	0.0366	0.0020	0.0079	< 0.00011	0.010	< 0.0050
^{232}Th	< 0.0018	0.0035	0.0068	0.0039	< 0.004	0.00077	0.0029	0.068	0.0039	0.019
^{234}U	0.37	0.34	0.42	0.70	0.46	0.16	0.036	0.0053	0.70	0.23
^{235}U	0.029	0.029	0.022	0.035	0.029	0.0061	0.0037	0.089	0.035	0.033
^{238}U	0.26	0.22	0.34	0.33	0.29	0.12	0.23	0.0073	0.033	0.098
^{238}Pu	0.00044	0.00093	0.00092	0.000091	0.00060	0.00051	0.00092	0.0089	0.00070	0.0028
^{239}Pu	0.012	0.043	0.014	0.0065	0.019	0.032	0.040	0.011	0.0048	0.068

*Not detectable.

Table 5

CONCENTRATION OF ^{131}I IN AIR AS MEASURED BY THE PERIMETER AIR MONITORING STATIONS[a]

1978

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-14} μCi/ml			%
			MAXIMUM[b]	MINIMUM[c]	AVERAGE	CG[d]
HP-31	Kerr Hollow Gate	52	5.94	0.04	0.73 ± 0.28	<0.01
HP-32	Midway Gate	52	8.36	0.07	0.82 ± 0.32	<0.01
HP-33	Gallaher Gate	51	6.88	0.03	0.84 ± 0.29	<0.01
HP-34	White Oak Dam	52	8.18	0.03	0.83 ± 0.32	<0.01
HP-35	Blair Gate	51	2.88	0.08	0.55 ± 0.13	<0.01
HP-36	Turnpike Gate	51	6.49	0.05	0.73 ± 0.25	<0.01
HP-37	Hickory Creek Bend	52	5.51	0.05	0.71 ± 0.21	<0.01
HP-38	East of EGCR	51	6.89	0.02	0.76 ± 0.27	<0.01
HP-39	Townsite	52	2.04	0.03	0.83 ± 0.28	<0.01
Average					0.75 ± 0.09	<0.01

[a]See Figure 1.

[b]Maximum weekly average concentration.

[c]Minimum weekly average concentration—minimum detectable amount of ^{131}I is 3×10^{-6} μCi per sample.

[d]CG is 1×10^{-10} μCi/ml (DOE Manual, Appendix 0524, Annex A, Table II).

Table 6

DISCHARGES OF RADIOACTIVITY TO THE ATMOSPHERE

1978

RADIONUCLIDE	CURIES DISCHARGED
Uranium[a]	0.03
^{131}I	1.7
^{3}H	2500
^{133}Xe[b]	<59000
^{85}Kr[b]	<12000
^{99}Tc	0.3
Pu[c]	4×10^{-6}
Alpha[d]	$<2 \times 10^{-8}$

[a]Uranium of varying enrichments - curie quantities calculated using the appropriate specific activity for material released.

[b]Upper limit values based on direct radiation instrument measurements in the stack gas stream and an assumed mixture of noble gases.

[c]Mixture of all isotopes.

[d]Unidentified alpha.

Table 7
AIR MONITORING DATA - FLUORIDES
1978

Location[a]	Number of Samples	Maximum Concentration for Averaging Interval μg/m³		Number of Times Standard Exceeded[b]		Annual Average μg/m³
	7 Day	7 Day	30 Day	7 Day	30 Day	
F-1	42	0.6	0.3	0	0	<0.2 ± 0.05
F-2	48	1.8	0.9	2	0	0.4 ± 0.1
F-3	43	0.7	0.3	0	0	0.2 ± 0.06
F-4	46	0.3	0.1	0	0	<0.08 ± 0.02
F-5	47	0.2	0.1	0	0	<0.07 ± 0.02
F-6[c]	46	0.2	0.1	0	0	<0.08 ± 0.02

[a]See Figure 1.

[b]Tennessee Air Pollution Control Regulations-
3.7 μg/m³ for 12 hour averaging interval
2.9 μg/m³ for 24 hour averaging interval
1.6 μg/m³ for 7 day averaging interval
1.2 μg/m³ for 30 day averaging interval
All values are maximum-not to be exceeded more than once per year

[c]Station F-6 approximately 8 kilometers from ORGDP upwind of the predominant prevailing wind direction, thus may be considered representative of general ambient background concentration.

NOTE: Data not amenable to comparison with 12-hour or 24-hour standard.

Table 8
AIR MONITORING DATA - SUSPENDED PARTICULATES
1978

LOCATION[a]	NUMBER OF SAMPLES	CONCENTRATION, $\mu g/m^3$			% STD.[b]
		MAXIMUM	MINIMUM	AVERAGE	
SP-1	45	322	2	38 ± 30	51
SP-2	45	387	8	35 ± 33	46
SP-3	44	259	9	37 ± 28	48
SP-4	41	240	9	42 ± 32	56

[a]See Figure 1.

[b]Tennessee Air Pollution Control Regulations - Primary standard based on annual geometric mean is 75.0 $\mu g/m^3$.

Table 9
SULFUR DIOXIDE MONITORING DATA
1978

MONTH	MAXIMUM 24 HR. AVERAGE (PPM)		MONTHLY AVERAGE (PPM)	
	STATION S-1	STATION S-2	STATION S-1	STATION S-2
January	.02	.09	.011	.033
February	No Data	.09	No Data	.036
March	No Data	.03	No Data	.017
April	.01	.01	.012	.009
May	.02	No Data	.007	No Data
June	.02	No Data	.018	No Data
July	.01	.04	.010	.015
August	.01	.02	.006	.012
September	.03	.04	.008	.022
October	.01	.10	.008	.025
November	.01	.04	.007	.038
December	.01	.22*	.006	.055*
Annual Arithmetic Mean			.009	.026

Tennessee Ambient Standards
Maximum 24 hr. Average -0.14 ppm
Annual Arithmetic mean -0.03 ppm
Minimum Detectable Limit -0.005 ppm

*System calibration in question.

Table 10
EXTERNAL GAMMA RADIATION MEASUREMENTS
1978

STATION NUMBER	LOCATION	NUMBER OF MEASUREMENTS TAKEN	BACKGROUND μR/hr	BACKGROUND mR/yr
		Perimeter Stations[a]		
HP-31	Kerr Hollow Gate	12	9.4 ± 0.4	83 ± 4
HP-32	Midway Gate	12	10.9 ± 1.0	95 ± 9
HP-33	Gallaher Gate	12	8.9 ± 0.8	78 ± 7
HP-34	White Oak Dam	12	12.8 ± 1.1	112 ± 10
HP-35	Blair Gate	12	8.6 ± 1.5	75 ± 14
HP-36	Turnpike Gate	12	8.8 ± 1.5	77 ± 12
HP-37	Hickory Creek Bend	12	7.7 ± 0.7	67 ± 6
HP-38	East of EGCR	12	9.4 ± 1.7	83 ± 15
HP-39	Townsite	12	8.7 ± 0.6	76 ± 5
Average			9.5 ± 0.3	83 ± 3
		Remote Stations[b]		
HP-51	Norris Dam	2	6.6 ± 3.0	58 ± 26
HP-52	Loudoun Dam	2	7.3 ± 1.3	64 ± 11
HP-53	Douglas Dam	2	7.7 ± 1.9	67 ± 17
HP-54	Cherokee Dam	2	6.9 ± 1.9	60 ± 16
HP-55	Watts Bar Dam	2	6.9 ± 1.1	60 ± 9
HP-56	Great Falls Dam	2	6.9 ± 1.5	60 ± 14
HP-57	Dale Hollow Dam	2	7.9 ± 0.6	69 ± 5
HP-58	Knoxville	2	14.3 ± 8.2	125 ± 71
Average			8.1 ± 2.0	70 ± 22

[a]See Figure 1.

[b]See Figure 2.

Table 11
RADIONUCLIDES IN THE CLINCH RIVER
1978

LOCATION	NUMBER OF SAMPLES	RANGE	CONCENTRATION OF RADIONUCLIDES OF PRIMARY CONCERN UNITS OF 10^{-9} μCi/ml					% CG[a]
			^{90}Sr	^{137}Cs	^{106}Ru	^{60}Co	^{3}H	
C-2 CRM 23.1	4	Max.	0.09	0.45	1.36	0.09	1100	
		Min.	0.09	0.05	0.14	0.05	300	0.06
		Avg.	0.09	0.24 ± 0.18	0.64 ± 0.60	0.07 ± 0.03	600 ± 400	
C-3 CRM 14.5	4	Max.	0.18	3.18	1.82	0.27	3600	
		Min.	0.09	0.05	0.09	0.05	1900	0.13
		Avg.	0.11 ± 0.05	1.17 ± 1.47	0.85 ± 0.87	0.16 ± 0.13	2200 ± 1000	
C-5 CRM 4.5	4	Max.	0.18	0.91	1.82	0.14	4100	
		Min	0.05	0.09	0.32	0.05	1000	0.12
		Avg.	0.10 ± 0.06	0.71 ± 0.41	0.73 ± 0.73	0.11 ± 0.05	2200 ± 1300	

[a]Most restrictive concentration guide for each isotope used for calculating percent concentration guide. The method for calculating percent of concentration guide for a known mixture of radionuclides is given in DOE Manual, Appendix 0524, Annex A.[1]

Table 12
URANIUM CONCENTRATION IN SURFACE STREAMS
1978

STATION NUMBER[a]	LOCATION	NUMBER OF SAMPLES	UNITS OF 10^{-8} μCi/ml			% CG[b]
			MAXIMUM	MINIMUM	AVERAGE	
P-1	Poplar Creek	12	0.7	<0.07	<0.3 ± 0.1	<0.1
P-2	Poplar Creek	12	1.4	<0.07	<0.4 ± 0.2	<0.1
C-3	Clinch River	12	0.4	<0.07	<0.1 ± 0.07	<0.1
C-4	Clinch River	12	2.1	<0.07	<0.3 ± 0.4	<0.1
C-6	Clinch River	12	0.7	<0.07	<0.3 ± 0.2	<0.1
E-1	East Fork Poplar Creek	12	1.9	0.5	1.1 ± 0.1	<0.1
B-1	Bear Creek	12	3.1	1.4	1.8 ± 0.01	<0.1

[a]See Figure 3.

[b]CG is 3×10^{-5} μCi/ml for a mixture of uranium isotopes (DOE Manual, Appendix 0524, Annex A, Table II).

Table 13
DISCHARGES OF RADIOACTIVITY TO SURFACE STREAMS
1978

RADIONUCLIDE	CURIES DISCHARGED
^{137}Cs	0.07
^{60}Co	0.4
^{3}H	6290
^{131}I	0.04
^{106}Ru	0.02
^{90}Sr	2
^{99}Tc	4
Uranium[a]	0.8
^{232}Th	0.009
Transuranics[b]	0.03

[a]Uranium of varying enrichments — curie quantities calculated using the appropriate specific activity for material released.

[b]Value based on gross transuranic alpha emitter analysis.

Table 14
LONG-LIVED GROSS BETA ACTIVITY IN RAINWATER
1978

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-8} μCi/ml[a]
		Perimeter Area[b]	
HP-31	Kerr Hollow Gate	39	1.06 ± 0.35
HP-32	Midway Gate	38	0.73 ± 0.25
HP-33	Gallaher Gate	36	1.43 ± 0.46
HP-34	White Oak Dam	41	1.04 ± 0.37
HP-35	Blair Gate	39	1.06 ± 0.35
HP-36	Turnpike Gate	40	0.80 ± 0.27
HP-37	Hickory Creek Bend	39	1.04 ± 0.36
HP-38	East of EGCR	40	1.87 ± 0.75
HP-39	Townsite	42	1.41 ± 0.48
Average			1.16 ± 0.14
		Remote Area[c]	
HP-51	Norris Dam	44	2.11 ± 0.82
HP-52	Loudoun Dam	37	2.46 ± 0.87
HP-53	Douglas Dam	37	1.54 ± 0.48
HP-54	Cherokee Dam	40	2.24 ± 0.76
HP-55	Watts Bar Dam	44	1.22 ± 0.49
HP-56	Great Falls Dam	36	2.18 ± 0.72
HP-57	Dale Hollow Dam	44	2.14 ± 0.83
HP-58	Knoxville	41	1.24 ± 0.50
Average			1.89 ± 0.25

[a]Weekly averaged concentrations.

[b]See Figure 1.

[c]See Figure 2.

Table 15
CHEMICAL WATER QUALITY DATA - WHITE OAK DAM
(Location W-1, Figure 3)
1978

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cr	12	0.04	<0.005	<0.008 ± 0.006	0.05	<16
Zn	12	0.01	<0.005	<0.005 ± 0.002	0.1	< 5
NO_3(N)	12	13.7	0.06	1.6 ± 2.2	10	16
Hg	12	< 0.0005	<0.0005	<0.0005	0.005	<10

[a]Tennessee Stream Guidelines.

Table 16
CHEMICAL WATER QUALITY DATA - MELTON HILL DAM
(Location C-2, Figure 3)
1978

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cr	12	<0.005	<0.005	<0.005	0.05	<10
Zn	12	0.005	<0.005	<0.005	0.1	< 5
NO_3(N)	12	4.5	<0.01	<0.5 ± 0.7	10	< 5
Hg	12	<0.0005	<0.0005	<0.0005	0.005	<10

[a]Tennessee Stream Guidelines.

Table 17
CHEMICAL WATER QUALITY DATA - ORGDP SANITARY WATER PUMPING STATION
(Location C-3, Figure 3)
1978

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.005	< 0.005	< 0.005	0.01	<50
Cr	12	0.01	< 0.005	< 0.006 ± 0.001	0.05	<12
CN	12	0.006	< 0.002	< 0.002 ± 0.0007	0.01	<20
$NO_3(N)$	12	1.0	< 0.01	< 0.6 ± 0.2	10	< 6
Pb	12	0.01	< 0.01	< 0.01	0.05	<20
$SO_4^=$	12	38	14	25 ± 4.6	250	10
T.D.S.	12	176	30	137 ± 25	500	27
Zn	12	0.4	0.01	0.08 ± 0.07	0.1	80
F^-	12	0.2	< 0.1	< 0.1	1.0	<10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	11	0.03	0.005	0.01 ± 0.004	0.1	10

[a]Tennessee Stream Guidelines

Table 18
CHEMICAL WATER QUALITY DATA - ORGDP RECIRCULATING WATER PUMPING STATION
(Location C-4, Figure 3)
1978

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.005	< 0.005	< 0.005	0.01	< 50
Cr	12	0.01	< 0.005	< 0.006 ± 0.001	0.05	< 12
CN	12	< 0.002	< 0.002	< 0.002	0.01	< 20
NO_3(N)	12	1.8	0.2	0.8 ± 0.2	10	8
Pb	12	< 0.01	< 0.01	< 0.01	0.05	< 20
$SO_4^=$	12	42	14	26 ± 4	250	10
T.D.S.	12	198	121	153 ±14	500	31
Zn	12	0.2	0.01	0.1 ± 0.05	0.1	100
F^-	12	0.4	< 0.1	< 0.2 ± 0.06	1.0	< 20
Hg	12	< 0.001	< 0.001	< 0.001	0.005	< 20
Ni	12	0.03	0.005	0.01 ± 0.004	0.1	10

[a]Tennessee Stream Guidelines

Table 19
CHEMICAL WATER QUALITY DATA - CLINCH RIVER DOWNSTREAM OF ORGDP
(Location C-6, Figure 3)
1978

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.007	< 0.005	< 0.005 ± 0.003	0.01	<50
Cr	12	0.009	< 0.005	< 0.005 ± 0.0007	0.05	<10
CN	12	0.006	< 0.002	< 0.002 ± 0.0007	0.01	<20
NO_3(N)	12	1.6	0.1	0.7 ± 0.2	10	7
Pb	12	0.02	< 0.01	< 0.01 ± 0.0005	0.05	<20
$SO_4^=$	12	47	13	22 ± 5	250	8
T.D.S.	12	172	92	135 ±15	500	27
Zn	12	0.05	0.006	0.02 ± 0.007	0.1	20
F^-	12	0.4	< 0.1	< 0.1 ± 0.05	1.0	<10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.02	0.006	0.01 ± 0.002	0.1	10

[a]Tennessee Stream Guidelines.

Table 20
CHEMICAL WATER QUALITY DATA - EAST FORK POPLAR CREEK
(Location E-1, Figure 3)
1978

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.01	< 0.002	< 0.003 ± 0.001	0.01	< 30
Cl^-	12	16	3	11.3 ± 2	250	4
Cr	12	0.05	< 0.01	< 0.02 ± 0.01	0.05	< 40
F^-	12	1.3	0.08	1.1 ± 0.01	1.0	110
Hg	12	0.002	< 0.0005	< 0.001 ± 0.0004	0.005	< 20
$NO_3(N)$	12	4	1	3 ± 0.6	10.0	30
Pb	12	0.01	< 0.01	< 0.01	0.05	< 20
$SO_4^=$	12	61	< 10	< 35 ± 8	250	< 14
T.D.S.	12	268	151	205 ± 20	500	41
Zn	12	0.03	< 0.02	< 0.02 ± 0.003	0.1	< 20

[a]Tennessee Stream Guidelines.

Table 21
CHEMICAL WATER QUALITY DATA - BEAR CREEK
(Location B-1, Figure 3)
1978

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.003	< 0.002	< 0.002 ± 0.001	0.01	<20
Cl^-	12	8	3	5 ± 2	250	2
F^-	12	0.3	< 0.01	< 0.2 ± 0.03	1.0	<20
$NO_3(N)$	12	14	4	9 ± 2	10	90
$SO_4^=$	12	16	<10	<11 ± 1	250	< 5
Zn	12	0.04	< 0.02	< 0.02 ± 0.004	0.1	<20

[a]Tennessee Stream Guidelines.

Table 22
CHEMICAL WATER QUALITY DATA - POPLAR CREEK ABOVE BLAIR BRIDGE
(Location P-1, Figure 3)
1978

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.006	< 0.005	< 0.005 ± 0.0001	0.01	<50
Cr	12	0.01	< 0.005	< 0.006 ± 0.001	0.05	<12
CN	12	0.01	< 0.002	< 0.003 ± 0.001	0.01	<30
NO_3(N)	12	2.2	0.3	1.2 ± 0.3	10	12
Pb	12	0.02	< 0.01	< 0.01 ± 0.002	0.05	<20
$SO_4^=$	12	54	22	34 ± 5	250	13
T.D.S.	12	243	134	194 ±24	500	39
Zn	12	0.08	< 0.005	< 0.05 ± 0.04	0.1	<50
F^-	12	0.6	< 0.1	< 0.3 ± 0.08	1.0	30
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.03	< 0.005	< 0.01 ± 0.005	0.1	<10

[a]Tennessee Stream Guidelines

Table 23

CHEMICAL WATER QUALITY DATA - POPLAR CREEK NEAR CLINCH RIVER

(Location P-2, Figure 3)

1978

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.005	< 0.005	< 0.005	0.01	<50
Cr	12	0.01	< 0.005	< 0.008 ± 0.002	0.05	<16
CN	12	0.004	< 0.002	< 0.002 ± 0.0003	0.01	<20
$NO_3(N)$	12	1.9	0.1	0.9 ± 0.3	10	9
Pb	12	0.02	< 0.01	< 0.01 ± 0.002	0.05	<20
$SO_4^{=}$	12	45	22	31 ± 4	250	12
T.D.S.	12	203	120	162 ± 14	500	32
Zn	12	0.08	0.01	0.03 ± 0.01	0.1	30
F^-	12	0.3	< 0.1	< 0.2 ± 0.03	1.0	<20
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.03	0.01	0.02 ± 0.004	0.1	20

[a]Tennessee Steam Guidelines.

Table 24
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) EXPERIENCE
1978

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/l	EFFLUENT LIMITS DAILY MAXIMUM mg/l	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
ORNL				
001				
(White Oak Creek)	Dissolved Oxygen (min.)	5	— —	100
	Dissolved Solids	— —	2000	100
	Oil and Grease	10	15	100
	Chromium (Total)	— —	0.05	94
	pH (pH units)	— —	6.0—9.0	98
002				
(Melton Branch)	Chromium (total)	— —	0.05	100
	Dissolved Solids	— —	2000	100
	Oil and Grease	10	15	100
	pH(pH units)	— —	6.0—9.0	100
003				
(Main Sanitary Treatment Facility)	Ammonia (N)	— —	5	48
	BOD	— —	20	88
	Chlorine Residual	— —	0.5—2.0	99
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	100
	pH (pH units)	— —	6.0—9.0	100
	Suspended Solids	— —	30	79
	Settleable Solids (ml/l)	— —	0.5	98
004				
(7900 Area Sanitary Treatment Facility)	BOD	— —	30	No Discharges From This Facility
	Chlorine Residual	— —	0.5—2.0	
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	
	pH (pH units)	— —	6.0—9.0	
	Suspended Solids	— —	30	
	Settleable Solids (ml/l)		0.5	
Y-12 PLANT				
001				
(Kerr Hollow Quarry)	Dissolved Solids	— —	2000	100
	Lithium	— —	5	100
	pH (pH units)	— —	6.0—9.0	100
	Suspended Solids	— —	50	100
	Zirconium	— —	3	No Disposals
002				
(Rogers Quarry)	pH (pH units)	— —	6.0—9.0	96
	Suspended Solids[a]	30	50	100
	Settleable Solids (ml/l)[a]	— —	0.5	100

Table 24
(CONTINUED)

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/l	EFFLUENT LIMITS DAILY MAXIMUM mg/l	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
003				
(New Hope Pond)	Ammonia (N)	--	1.6	100
	Chromium	0.05	0.08	100
	Dissolved oxygen (Min.)	5	--	100
	Dissolved Solids	--	2000	100
	Fluoride	1.5	2.0	92
	Lithium	--	5	100
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0—9.0	100
	Phosphate (as MBAS)	5	8	100
	Suspended Solids[a]	--	20	100
	Settleable Solids (ml/l)[a]	--	0.5	100
	Total Nitrogen (N)	--	20	100
	Zinc	0.1	0.2	100
004				
(Bear Creek)	Oil and Grease	10	15	100
	pH (pH units)	--	6.0—8.5	100
ORGDP				
001				
(K-1700 Discharge)	Aluminum	--	1.0	100
	Chromium (Total)	0.05	0.08	100
	Nitrate	--	20	100
	Suspended Solids	30	50	100
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0—9.0	99
002				
(K-1410 Metal	Cyanide		None Detectable	100
Plating Facility)	Oil and Grease	10	15	100
	pH (pH units)	--	6.0—9.0	99
004				
(K-1131 Steam	pH (pH units)	--	6.0—9.0	100
Condensate	Flow (MGD)	0.005	0.008	100
Discharge)				
005				
(K-1203 Sanitary	Ammonia (N)	5[b]	7[c]	100
Treatment Facility)	BOD	15[b]	20[c]	99
	Chlorine Residual	--	0.5—2.0	98
	Dissolved Oxygen (Min.)	5	--	99
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	100
	pH (pH units)	--		
	Suspended Solids	30[b]	45[c]	88
	Settleable Solids (ml/l)	--	0.5	90

Table 24
(CONTINUED)

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/l	EFFLUENT LIMITS DAILY MAXIMUM mg/l	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
006				
(K-1007B Holding	COD	20	25	100
Pond)	Chromium	— —	0.05	100
	Dissolved Oxygen (Min.)	5	— —	100
	Fluoride	1.0	1.5	100
	Oil and Grease	10	15	100
	pH (pH units)	— —	6.0—9.0	99
	Suspended Solids[a]	30	50	100
007				
(K-901A Holding	Chromium (total)	— —	0.05	98
Pond)	Fluoride	1.0	1.5	100
	Oil and Grease	10	15	100
	pH (pH units)	— —	6.0—10	100
	Suspended Solids	30	50	100
008[d]				
(K-710 Sanitary	BOD	30[b]	45[c]	100
Treatment Facility)	Suspended Solids	30[b]	45[c]	100
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	100
	pH (pH units)	— —	6.0—9.0	100
	Chlorine Residual	— —	0.5—2.0	98
	Settleable Solids (ml/l)	— —	0.1	100
009	Suspended Solids[a]	30	50	100
(Sanitary Water	Aluminum	— —	250	100
Plant)	Sulphate	— —	1400	100
	pH (pH units)	— —	6.0—9.0	100

[a] Limit applicable only during normal operations. Not applicable during periods of increased discharge due to surface run-off resulting from precipitation.

[b] Monthly Average.

[c] Weekly Average.

[d] Due to the small flow rates at the K-710 Sanitary Treatment Facility, a rapid sand filter was installed May 1, 1978 eliminating the surface discharge and monitoring requirements. Data reported represents the first four months of 1978.

Table 25

CONCENTRATION OF ^{131}I IN MILK[a]

1978

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF 10^{-9} μCi/ml			COMPARISON WITH STANDARD[c]
		MAXIMUM	MINIMUM[b]	AVERAGE	
		Immediate Environs[d]			
1	49	4.0	<0.45	<0.71 ± 0.21	Range I
2	50	3.2	<0.45	<0.60 ± 0.15	Range I
3	50	7.4	<0.45	<0.78 ± 0.31	Range I
4	45	14.9	<0.45	<0.94 ± 0.65	Range I
5	49	3.4	<0.45	<0.65 ± 0.19	Range I
6	49	23.0	<0.45	<1.26 ± 1.06	Range I
7	48	4.9	<0.45	<0.62 ± 0.21	Range I
8	47	1.7	<0.45	<0.53 ± 0.08	Range I
Average				<0.76 ± 0.15	
		Remote Environs[e]			
51	10	2.9	<0.45	<0.70 ± 0.49	Range I
52	6	<0.45	<0.45	<0.45	Range I
53	10	1.8	<0.45	<0.59 ± 0.27	Range I
54	8	<0.45	<0.45	<0.45	Range I
55	9	2.5	<0.45	<0.68 ± 0.46	Range I
Average				<0.59 ± 0.15	

[a]Raw milk samples, except for station 2 which is a dairy.

[b]Minimum detectable concentration of ^{131}I is 0.45×10^{-9} μCi/ml.

[c]Applicable FRC standard, assuming 1 liter per day intake:

Range I	0 to 1×10^{-8} μCi/ml	– Adequate surveillance required to confirm calculated intakes.
Range II	1×10^{-8} μCi/ml to 1×10^{-7} μCi/ml	– Active surveillance required.
Range III	1×10^{-7} μCi/ml to 1×10^{-6} μCi/ml	– Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[d]See Figure 6.

[e]See Figure 7.

U in CR fish

Table 26
CONCENTRATION OF ^{90}Sr IN MILK[a]
1978

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF 10^{-9} μCi/ml			COMPARISON WITH STANDARD[c]
		MAXIMUM	MINIMUM[b]	AVERAGE	
		Immediate Environs[d]			
1	47	4.3	1.6	2.6 ± 0.17	Range I
2	50	5.0	1.1	2.2 ± 0.21	Range I
3	48	3.9	1.4	2.3 ± 0.16	Range I
4	46	4.6	1.6	2.4 ± 0.22	Range I
5	48	7.7	1.8	3.1 ± 0.31	Range I
6	48	9.1	2.7	6.0 ± 0.51	Range I
7	47	5.5	1.4	2.8 ± 0.22	Range I
8	45	5.9	1.6	3.0 ± 0.30	Range I
Average				3.1 ± 0.10	
		Remote Environs[e]			
51	10	3.4	0.9	1.9 ± 0.55	Range I
52	6	1.8	0.9	1.4 ± 0.25	Range I
53	10	5.7	0.9	3.3 ± 0.88	Range I
54	8	4.1	1.6	2.2 ± 0.59	Range I
55	10	5.0	1.1	3.0 ± 0.62	Range I
Average				2.5 ± 0.27	

[a]Raw milk samples, except for station 2 which is a dairy.

[b]Minimum detectable concentration of ^{90}Sr in milk is 0.5×10^{-9} μCi/ml.

[c]Applicable FRC Standard, assuming 1 liter per day intake:

Range I 0 to 2×10^{-8} μCi/ml - Adequate surveillance required to confirm calculated intakes.

Range II 2×10^{-8} μCi/ml to 2×10^{-7} μCi/ml - Active surveillance required.

Range III 2×10^{-7} μCi/ml to 2×10^{-6} μCi/ml - Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[d]See Figure 6.

[e]See Figure 7.

Table 27

RADIONUCLIDE CONTENT IN CLINCH RIVER FISH

1978

pCi/kg Wet Weight

Location	Species[a]	^{90}Sr	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U	^{137}Cs	^{60}Co	^{40}K	% MPI[b]	Hg(ng/g)	% of A.L.[c]
CRM 4.0	Bass	1.8	0.01	0.10	0.08	0.01	0.10	121	5.1	4117	0.03	3.5	0.7
	Blue Gill	7.8	0.07	0.08	0.16	0.16	0.34	608	10.7	4489	0.20	17.0	3.4
	Carp	4.5	0.01	0.01	0.27	0.08	0.59	76	0.1	3280	0.03	2.8	0.6
	Shad	3.7	0.04	0.02	1.90	0.26	2.23	106	13.6	3101	0.05	1.6	0.3
CRM 5.0	Bass	1.7	0.01	0.01	0.12	0.06	29.26	136	0.4	3830	0.15	7.2	1.4
	Blue Gill	3.2	0.02	0.01	0.39	0.16	0.39	122	12.0	4254	0.04	9.0	1.8
	Carp	4.6	0.01	0.01	0.23	0.17	0.41	348	0.4	2258	0.07	5.9	1.2
	Shad	5.9	0.01	0.01	0.29	0.15	0.21	181	0.5	4743	0.06	1.2	0.2
CRM 12.0	Bass	0.6	0.02	0.03	0.03	0.13	0.38	166	3.8	3891	0.18	1.9	0.4
	Blue Gill	4.9	0.03	0.02	2.63	0.42	2.77	94	6.3	3727	0.04	2.7	0.5
	Carp	2.9	0.01	0.01	1.20	0.24	1.20	71	2.9	3644	0.03	6.0	1.2
	Shad	5.5	0.16	0.22	4.20	0.47	3.89	23	11.6	5052	0.04	4.5	0.9
	Crappie	11.9	0.12	0.12	0.59	0.48	0.59	12	20.2	3590	0.09	7.6	1.5
CRM 20.8[d]	Bass	42.2	0.03	0.01	0.16	0.07	0.24	10287	28.2	3925	0.51	3.1	0.6
	Blue Gill	128.0	0.18	0.75	0.39	0.14	0.53	3369	79.2	3912	1.25	3.2	0.6
	Carp	33.5	0.02	0.01	0.48	0.06	0.67	440	12.6	2044	0.28	3.1	0.6
	Shad	59.8	0.05	0.11	3.33	0.23	5.06	1208	30.7	2852	0.54	0.7	0.1
	Crappie	41.0	0.12	0.54	0.44	0.18	2.77	3293	16.6	4903	0.56	3.7	0.7
CRM 22.0	Bass	9.5	0.02	0.02	0.56	0.01	0.22	61	15.0	3890	0.07	4.3	0.8
	Blue Gill	19.3	0.03	0.02	0.23	0.30	0.68	175	23.2	3617	0.15	5.0	1.0
	Carp	2.6	0.01	0.01	0.06	0.06	0.23	164	3.8	3840	0.03	1.4	0.3
	Shad	4.8	0.01	0.01	1.86	0.04	2.70	300	14.5	3350	0.07	0.6	0.1
	Crappie	4.8	0.05	0.01	0.13	0.12	0.45	48	7.9	3168	0.01	0.8	0.2
CRM 24.0	Bass	1.3	0.01	0.01	0.21	0.04	0.28	96	4.7	3428	0.02	0.8	0.2
	Blue Gill	3.1	0.06	0.03	0.14	0.13	0.32	12	7.8	3744	0.02	3.4	0.7
	Carp	1.5	0.17	0.03	0.08	0.03	0.14	25	3.6	3648	0.01	1.5	0.3
	Shad	2.4	0.01	0.01	0.92	0.14	1.15	27	5.5	3288	0.02	0.1	0.03

[a]Composite of 10 fish in each species.

[b]Maximum Permissible Intake - Intake of radionuclide from eating fish is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing the concentration guide of radionuclides in question. Consumption of fish is assumed to be 16.8 kg/yr of the species in question. Only man-made radionuclides were used in the calculation.

[c]Percent of proposed FDA action level of 500 ng/g.

[d]Average of quarterly samples.

Table 28
RADIONUCLIDE CONCENTRATIONS IN DEER SAMPLES
1978
pCi/kg Wet Weight

SAMPLE NUMBER	LOCATION	SEX	ORGAN	^{137}Cs	^{40}K
1	New Zion Road 1/4 mile east of Racoon Creek Road	F	Liver	10.2	1290
2	Highway 95 1/2 mile south of Junction 58	F	Liver	50.9	1650
3*	Highway 58 1/4 mile east of Blair Road	M	Liver	27.3	1530
4	Blair Road 1/4 mile south of Poplar Creek	M	Liver Heart	11.9 24.7	2190 1380

*This sample also contained 21 pCi/kg of ^{65}Zn.

Table 29
VEGETATION SAMPLING DATA
1978

STATION NUMBER[a]	F^- CONCENTRATION[b] µg/g (ppm)		U (TOTAL) CONCENTRATION[b] µg/g (ppm)	
	GRASS	PINE NEEDLES	GRASS	PINE NEEDLES
1	11	--	0.2	--
2	12	8	0.05	0.04
3	11	12	0.04	0.06
4	11	9	0.2	0.2
5	16	12	0.3	0.2
6	10	7	0.6	0.04
7	9	8	0.5	0.09
8	19	18	1.0	0.2
9	10	14	0.4	0.2
10	23	7	0.4	0.1
11	29	17	1.2	0.5
12	12	16	0.4	0.2
13	19	--	0.8	--
14	9	--	0.3	--
15	27	--	0.3	--
16	12	--	0.5	--
17	20	--	1.1	--

[a]See Figure 1.

[b]Average concentration of two sample collections, January and July. Analytical results are on a dry weight basis.

NOTE: Applicable guides for flora have not been established. However, for comparison the *American Industrial Hygiene Association Journal* for January-February 1969 (pp. 98-101) states that dairy cattle is the species of livestock most sensitive to fluorides in grasses. For comparative purposes the following fluoride concentrations and their effect on dairy cattle are given.

30 ppm	-	no adverse effects
30 to 40 ppm	-	borderline chronic
40 to 60 ppm	-	moderate chronic
60 to 110 ppm	-	severe chronic
above 250 ppm	-	acute

Table 30

RADIOACTIVITY IN GRASS SAMPLES FROM PERIMETER AND REMOTE MONITORING STATIONS

1978

(Units of pCi/g—Dry Weight)

SAMPLING LOCATION[a]	^{7}Be	^{90}Sr	^{137}Cs	^{144}Ce	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U	^{232}Th	^{230}Th	^{228}Th
						Perimeter[b]						
HP-31	17	.7	.4	3	.003	.001	.06	.007	.11	.04	.03	.05
HP-32	19	.7	.3	2	.002	.001	.07	.018	.19	.02	.02	.06
HP-33	17	.5	.4	3	.004	.002	.05	.005	.06	.02	.02	.03
HP-34	13	.5	.4	3	.003	.001	.02	.002	.02	.02	.02	.051
HP-35	18	.4	.3	3	.003	.001	.07	.007	.11	.03	.03	.07
HP-36	15	.6	.3	2	.004	.001	.07	.005	.08	.04	.04	.04
HP-37	17	.7	.3	2	.003	.001	.04	.004	.04	.02	.02	.02
HP-38	16	.5	.5	4	.002	.001	.10	.004	.04	.01	.01	.04
HP-39	18	.4	.3	3	.004	.001	.05	.005	.11	.01	.02	.04
Average	17	.6	.4	3	.003	.001	.06	.005	.08	.02	.02	.04
						Remote[c]						
HP-51	16	.3	.1	1	<.002	<.0013	.02	.002	.004			
HP-52	17	.6	.2	1	.001	<.0002	.02	.002	.01			
HP-53	8	.4	.1	1	.001	<.0001	.01	.001	.01			
HP-54	11	.5	.6	4	.003	.0003	.07	.006	.08			
HP-55	16	.2	.2	1	.002	.0014	.03	.006	.03			
HP-56	15	.7	.1	1	.001	<.0005	.02	.008	.02			
HP-57	11	.8	.2	2	.003	<.0005	.02	.004	.02			
HP-58	12	.8	.2	1	.018	<.0005	.003	.008	.03			
Average	13	.5	.2	2	<.004	<.0006	.02	.005	.03			

[a]See Figures 1 and 2

[b]Average of two samples

[c]One sample

Table 31

RADIOACTIVITY IN SOIL SAMPLES FROM PERIMETER AND REMOTE MONITORING STATIONS

1978

(Units of pCi/g—Dry Weight)

SAMPLING LOCATION[a]	^{90}Sr	^{137}Cs	^{226}Ra	^{234}U	^{235}U	^{238}U	^{238}Pu	^{239}Pu	^{232}Th	^{230}Th	^{228}TH
					Perimeter[b]						
HP-31	.5	2	1.0	.52	.02	.30	.001	.03	.24	.17	.27
HP-32	.9	2	0.8	.99	.04	.60	.002	.03	.33	.20	.37
HP-33	.4	3	0.8	.44	.01	.30	.002	.04	.19	.16	.21
HP-34	.5	3	1.0	.35	.02	.24	.001	.04	.37	.20	.47
HP-35	.5	2	0.8	.48	.03	.36	.003	.04	.26	.20	.24
HP-36	.6	2	1.0	.52	.02	.38	.002	.04	.29	.26	.34
HP-37	.5	1	1.0	.26	.02	.21	.0004	.02	.36	.31	.42
HP-38	.4	1	1.0	.28	.01	.21	.001	.02	.35	.22	.45
HP-39	.4	3	1.2	.67	.03	.26	.001	.03	.26	.34	.30
Average	.5	2	1.0	.50	.02	.32	.002	.03	.29	.23	.34
					Remote[c]						
HP-51	.3	1	1.2	.70	.02	.60	.0005	.03			
HP-52	.4	3	0.8	.50	.01	.39	.0009	.02			
HP-53	.3	2	1.8	.90	.14	.80	.0018	.03			
HP-54	.2	.3	<1.0	.22	.01	.17	.0005	.004			
HP-55	.4	2	1.3	.42	.02	.35	.0009	.02			
HP-56	.5	2	1.1	.39	.01	.35	.0009	.03			
HP-57	.8	3	1.1	.39	.01	.37	.0009	.05			
HP-58	.3	2	1.3	.50	.02	.44	.0070	.02			
Average	.4	2	<1.2	.50	.03	.43	.0017	.03			

[a]See Figures 1 and 2

[b]Average of two samples

[c]One sample

Table 32
STREAM SEDIMENT SAMPLES
July/November 1978
Average Concentration (μg/g dry weight basis)

STATION	U	Hg	Pb	Ni	Cu	Zn	Cr	Mn	Cd	Al	Th
CS1	16	< 0.2	30	30	20	60	43	1875	<5	34000	<40
PS2	15	7	63	86	114	124	100	546	<5	102000	<40
PS5	9	2	39	53	41	100	59	798	<5	56000	<40
PS6	14	8	42	94	53	159	129	511	<5	62000	<40
PS9	4	2	47	59	57	86	71	929	<5	52000	<40
PS10	21	17	37	187	58	149	60	562	<5	40000	<40
PS12	17	6	47	69	42	96	53	715	<5	46000	<40
PS15	95	21	65	388	165	169	237	520	<5	50000	<40
PS17	12	< 2	46	50	36	72	47	973	<5	46000	<40
PS18	6	5	45	37	36	74	48	539	<5	42000	<40
PS19	9	14	54	36	61	69	48	813	<5	46000	<40
PS21	13	6	55	82	100	125	79	765	<5	84000	<40
PS22	10	3	47	60	37	98	52	746	<5	50000	<40
CS20	8	< 0.2	35	50	40	90	57	1105	<5	59000	<40

NOTE: An evaluation of the Clinch River and Poplar Creek hydrology resulted in the addition of two new sampling points (PS21 and PS22) and the deletion of eight sampling points, which provided for a more representative sampling program.

Table 33
SUMMARY OF THE ESTIMATED RADIATION DOSE
TO AN ADULT INDIVIDUAL DURING 1978 AT LOCATIONS OF MAXIMUM EXPOSURE

PATHWAY	LOCATION	DOSE (MILLIREM) TOTAL BODY	DOSE (MILLIREM) CRITICAL ORGAN
Gaseous Effluents			
Inhalation plus direct radiation from air and ground	Nearest resident to site boundary	0.14 ± 150%	1.0 ± 150% (lung)
Terrestrial food chains	Milk sampling stations(^{90}Sr)	0.21	10.3 (bone)
Liquid Effluents			
Aquatic food chains	Clinch-Tennessee River system(^{137}Cs)	13.6	34.5 (liver)
Drinking water[a]	Kingston, Tennessee (^{90}Sr)	0.0002	0.01 (bone)
Direct radiation along water, shores, and mud flats.[b]	Downstream from White Oak Creek near experimental Cs field plots	6.7	6.7 (total body)

[a]Based on the analysis of raw (unprocessed) water; see text.

[b]Assuming a residence time of 240 hr/yr.

NOTE: Average background total body dose in the U.S.,[30] is 106 mrem/yr.

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APPENDIX A
QUALITY ASSURANCE

Radiological

The Environmental Surveillance and Evaluation Section at Oak Ridge National Laboratory has initiated a quality assurance program to ensure that a high degree of accuracy and reliability is maintained in its surveillance activities. The program in effect at ORNL consists of quality control of techniques and procedures, and includes the establishment of a detailed written description of all activities pertaining to the Environmental Surveillance and Evaluation Section. This includes:

1. Operating procedures for each activity.
2. Inspection lists of operating and maintenance activities.
3. Check-off frequency lists for all quality assurance steps, such as schedules for equipment inspection and test control.
4. Documentation of compliance of quality assurance procedures.
5. Participation in intralaboratory and interlaboratory sample-exchange programs.
6. Evaluation of the adequacy of sample preparation work and data analysis.
7. Identification of the role, responsibilities, and authority of each staff member as related to quality assurance.

A schematic diagram showing a flow chart of this quality assurance program is given in Figure A1. A more detailed discussion of the ORNL QA program is given in Ref. (A1) and (A2).

Chemical

A Nuclear Division Committee on Environmental Analysis established an interlaboratory quality control program in 1977. The purpose of this program is to provide quality control data for environmental analysis within the Nuclear Division. A unified Environmental and Effluent Analysis Manual was issued in March of 1977 which contains 38 analytical procedures; EPA-certified analytical methods were used wherever possible.

All Nuclear Division analytical laboratories maintain internal measurement control programs that are part of planned and systematic actions taken to prevent incorrect results. Standard samples containing all parameters measured are purchased and submitted to the laboratories for analysis. Standard samples of known values are processed along with routine samples and the results are recorded and examined to determine if they fall within prescribed limits. Analytical results are transmitted to the Y-12 Plant Quality Control Department for statistical review and a semi-annual report is provided to the analytical laboratories.

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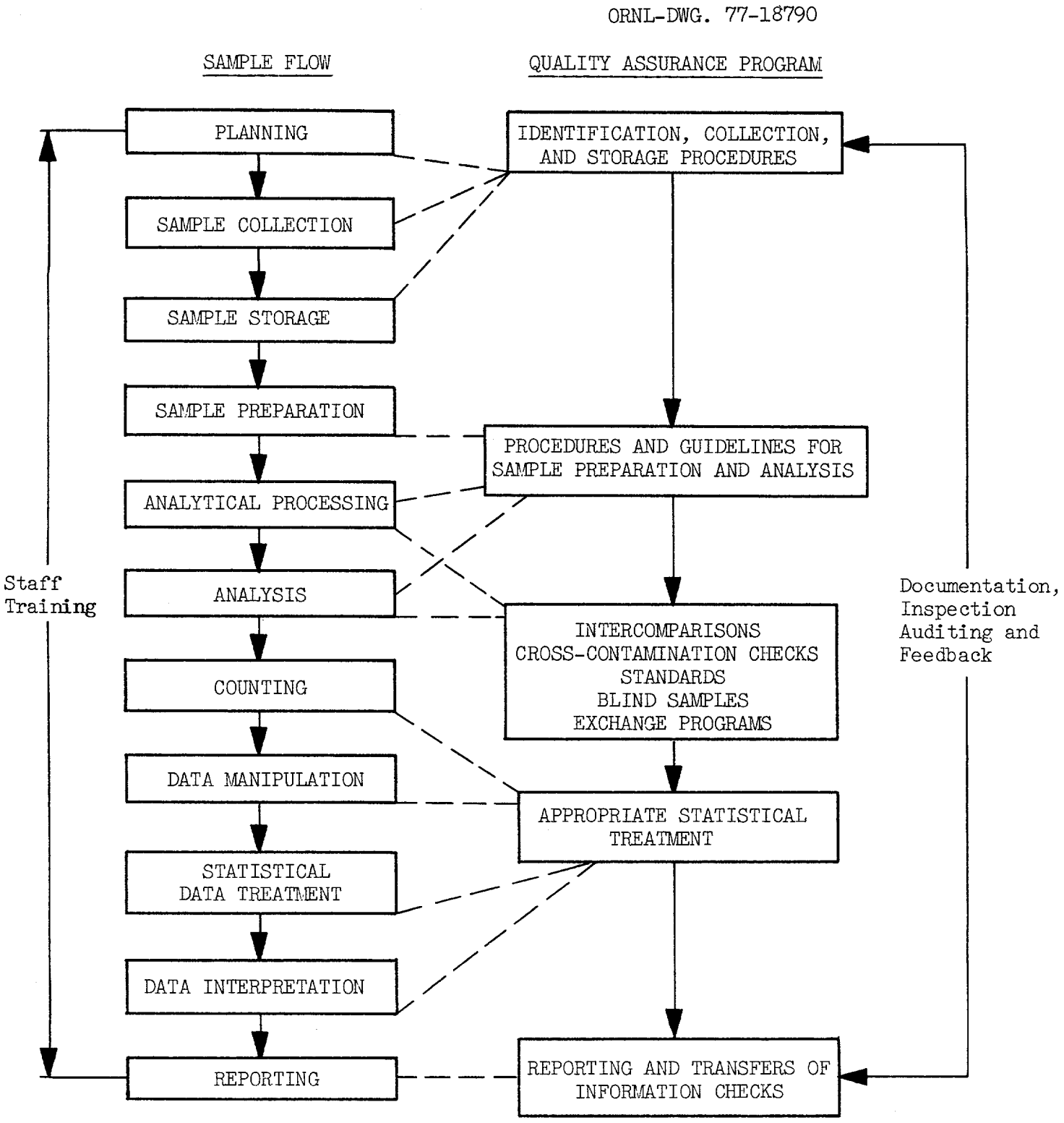

Figure A1
FLOW CHART OF QA PROGRAM

EXTERNAL DISTRIBUTION

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Tennessee State Health Department
Director, Tennessee State Health Department
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